MANUAL OF BOTANY:

COMPRISING

VEGETABLE ANATOMY AND PHYSIOLOGY,

OR

THE STRUCTURE AND FUNCTIONS OF PLANTS,

WITH REMARKS ON CLASSIFICATION.

BY

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ADVERTISEMENT.

It has appeared to the author of this *Manual*, that although many excellent treatises on the Structure, Functions, Distribution, and Classification of Plants, have been published in this country, and have contributed to extend among us the knowledge of those most interesting subjects, none of them is precisely fitted for the purpose of affording a concise and yet comprehensive view of the vegetable kingdom, such as might be useful to persons desirous of obtaining correct information at as little expense of time and labour as possible. The writings of Dr. Withering, Sir James E. Smith, Sir William Jackson Hooker, Professor Henslow, Professor Lindley, Dr. Greville, and other eminent botanists among ourselves, and of the many illustrious cultivators of botanical science in France, Germany, Switzerland, and North America, afford abundant materials for a treatise of the kind required. A practical acquaintance with the subject derived from continued observation, experience obtained by teaching it for several years, and an enthusiastic devotion to the study of natural history in general, together with a taste for methodical arrangement, might enable one to select the most important facts, and to present them in a perspicuous point of view, so as to supply the student with a useful Introduction to the study of Botany. The present treatise contains a condensed account of the

Structure and Functions of Plants, or of Vegetable Anatomy, Organography, and Physiology, together with the modifications of form and texture presented by the organs, and the terms by which they are distinguished. As the last are of especial importance with reference to the Classification and Description of Plants, subjects to be treated of in another volume, they have been repeated and explained in an Alphabetical Glossary at the end of the treatise. The works which have afforded the author the most important aid are those of Linnæus, De Candolle, Mirbel, Dutrochet, Richard, Smith, Lindley, and Henslow. To these are to be added the excellent *Manual* of M. Delafosse, and Dr. Thomson's *Organic Chemistry*. The Illustrations used, with the exception of the woodcuts, are those of Smith's *Introduction to Botany*. The arrangement adopted, which in some parts is similar to that of Professor Henslow, the author can state, from experience in teaching, to be well adapted for communicating a knowledge of the subjects treated of.

The great success of the *Manual of Geology*, and the favourable reports respecting it which have emanated from many individuals, some of them of the highest rank as geologists, induce the author of the present volume to hope that it may prove equally acceptable, and not less useful.

INTRODUCTION.

I. Botany is the Science which treats of Plants. It is not confined to the Arrangement and Description of these bodies, but embraces all that relates to their Structure, Functions, and Distribution. The name of this science is derived from a Greek word, *βοτανη*, signifying grass or herbage. As natural bodies are disposed into three great classes, Minerals, Vegetables, and Animals, and as the study of the first of these is named Mineralogy, while that of the last is named Zoology, both Greek compounds signifying the Doctrine of Minerals and the Doctrine of Animals, so the Doctrine or Study of Plants ought to be named Botanology, or Phytology, these terms being composed of *λογος*, logos, doctrine, or discourse, and *βοτανη*, above explained, or *φυτον*, phyton, a plant or vegetable.

II. Natural bodies or objects may be primarily disposed into two vast series. Some are formed by the aggregation of elementary particles or molecules, determined by the general laws of physics, and, although often symmetrical, are not composed of parts or organs adapted for the performance of functions having reference to the growth, propagation, or preservation of the individuals. Such bodies are therefore named Inorganic. Others are composed of parts or organs, mutually subservient, and are named Organic Bodies. They are possessed of life, whereas the former are destitute of that property. They all originate from a minute body, gradually enlarge by receiving into their interior particles from without, reproduce bodies similar to themselves, gradually decrease

in vigour, and at length die. These organized bodies are separated into two classes, ANIMALS and PLANTS, the systematic or connected study of all that relates to which constitutes the sciences of Zoology and of Botany.

III. In examining animals or vegetables, with the view of acquiring a correct knowledge of them, it is not sufficient to take note of their external appearance, inspect their organs in a superficial manner, watch the changes which gradually take place in them, or observe their motions and habits. These changes and actions result from their internal structure, and, before we can understand them aright, we must make ourselves acquainted with that structure. Two sciences, or branches of science, take cognizance of the mechanism and functions of the organs of animals and plants. That which has reference to the form, structure, and disposition of the organs, is named ANATOMY; while to PHYSIOLOGY belong their functions, or the offices which they perform. We have thus, in Zoology, the distinct, but connected branches of ZOOLOGICAL ANATOMY or ZOOTOMY, and ANIMAL PHYSIOLOGY; and in Botany the corresponding departments of VEGETABLE ANATOMY or PHYTOTOMY, and VEGETABLE PHYSIOLOGY. These sciences, when applied to the entire series of animals, or to that of plants, with the view of discovering their similitudes, discrepancies, and relations, of disclosing the modifications of their various organs, the laws which determine the mutual relations of these organs, and the connection between the form, habits, and external circumstances of the objects examined, assume the names of COMPARATIVE ANATOMY and PHYSIOLOGY.

IV. Now, in treating of Plants generally, we shall have, in the first place, to examine their various organs, both externally and internally, and then to discover their functions. These objects being very numerous, and

highly diversified in form and colour, it is necessary to arrange them into groups, to describe the species, and assign them distinctive characters and names. Each of these three great divisions of Botany, namely, VEGETABLE ANATOMY or ORGANOGRAPHY, as it is also called, VEGETABLE PHYSIOLOGY, and the CLASSIFICATION OF PLANTS, is composed of several subordinate sections, which it is not necessary here to specify, as the multiplicity of terms used in Botany is apt to bewilder the beginner, who can only, by a slow and gradual progress, render himself familiar with them. From what has been stated in this paragraph, it will appear that by Botany is here meant the Science which examines the structure and form of plants, determines their functions, and describes, distinguishes, names, and arranges them. The distribution of plants over the globe, their uses in the economy of nature, their application to purposes especially subservient to the welfare of the human species, and other circumstances usually enumerated in definitions, may all be referred to the above, although in teaching the elements of the science, it may be expedient to treat of them separately.

V. The study of Botany recommends itself in various ways. It may, to some extent, be engaged in by individuals of either sex, and of almost every profession. While Zoology, by the destruction of life, the disgust at first excited by dissection, the difficulty of procuring objects, and the necessity of extended journeys and inurement to fatigue, is, in some of its departments at least, repulsive to females; Botany, by the beauty of its objects, the facility with which they may be procured, and the agreeable images and associations which they call up in the mind, seems peculiarly adapted for them. Although a simple study, when pursued merely so far as to learn the names of plants, it is capable of calling into

action the higher faculties of the intellect. Indeed, natural history in general, if we judge of the difficulty of a subject by the want of success of those who strive to master it, seems to be a far more intellectual pursuit than is generally imagined. How many warriors, statesmen, poets, and novelists, have distinguished themselves by the successful exercise of their talents, compared with the very small number of really eminent naturalists? Greece produced but one great naturalist, Rome none, and modern Europe, for a hundred warriors, can scarcely show half a dozen of philosophic zoologists or botanists. Yet, strange as it may seem, every individual is in some respect a naturalist, and plants and animals excite the curiosity even of infants. Would that the study of botany, in particular, were made a subject of elementary instruction; for then the young would find in it an inducement to forego much of the vicious practices in which, through mere idleness, they are prone to engage. No pursuit can be more conducive to health, or, unless indulged in to excess, to mental serenity. But although a familiarity with nature may seem necessarily to render religious sentiments habitual, experience shows us, that piety and proficiency in natural history do not always go together. Still, he who is truly pious will find in the study of botany much to gratify his feelings; and he who is not, may meet with much to excite his admiration of the skill and contrivance displayed in the structure and distribution of plants.

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SECTION I.

STRUCTURE OF PLANTS.

CHAPTER I.

GENERAL CHARACTERS OF PLANTS.

NATURE OF PLANTS CONSIDERED GENERALLY. DISTINCTION BETWEEN PLANTS AND ANIMALS. APPARENT MOTILITY OF PLANTS NOT DEPENDENT UPON SENSIBILITY. ANALOGIES OF PLANTS AND ANIMALS. DIVISIONS.

1. *General Idea of Plants.—A Plant or Vegetable* may be defined an organized living body, destitute of sensibility and voluntary motion. Such a definition, however, although a better cannot be given, affords no precise idea of the nature of a plant. Such is the diversity among the vegetable productions of the globe, as to form, stature, texture, colour, and other qualities, that the definition applicable to all, excludes the more obvious properties of any of them. An oak, at first sight, seems to bear no resemblance to a mushroom; a palm-tree and a lichen are, in many respects, very dissimilar; a blade of seaweed and a stalk of wheat have little in common. Yet not only are these all plants, but every organized body not belonging to the animal kingdom, whether it shoot up to the height of a hundred feet, or more, or scarcely raise itself a twelfth of an inch from the surface of the earth or rock,—whether its texture be hard, like that of the oak, or soft as jelly,—whether it be divided into numberless branches, clothed with thousands of leaves,

and adorned with many beautiful and fragrant flowers, or in the total absence of such organs, present not even a determinate form,—is a vegetable, and must not be overlooked in attempting to form a general definition. There is not a single organ that presents itself in every plant: one has no root, another no stem, a third no leaves, a fourth no flowers. To increase our perplexity, some plants seem so nearly allied to some animals, that we can hardly say where the series of vegetables ends, and that of animals commences.

2. *Essential Distinction between Plants and Animals.*—Animals being possessed of sensibility and the power of motion, are enabled to search for and select the substances capable of affording them nourishment; and having introduced them into their alimentary cavity, convert them into a substance containing the elements of their various organs. Their food consists of all kinds of animal and vegetable substances, for the assimilation of which the digestive organs are greatly modified in the different species. But plants, being always fixed in a particular spot, and thus incapacitated from searching for food, are nourished by the substances which surround them, and imbibe or absorb, by their external surface, the atmospheric air, water, and matters dissolved in them. Having thus little choice, their organs of nutrition present little diversity. As the parts of the animal body cannot preserve a fixed position, while those of the vegetable undergo no perceptible displacement, the motion of the nutritious fluids must, in the former, depend upon internal impulses, while, in the latter, it is excited by causes acting from without, and unconnected with the organization, such as heat, evaporation, and moisture. Although animals and vegetables are formed of the same chemical elements, namely, oxygen, hydrogen, carbon, and nitrogen, the last of these substances prevails in ani-

mals, while carbon is the principal constituent of plants. Lastly, the organs of sensation and motion being nerves and muscles, vegetables are necessarily destitute of these elementary organs. Consequently, they have no heart, or central organ of circulation,—no vessels resembling arteries, veins, lacteals, or lymphatics.

3. *Apparent Motility in some Plants.*—Although, in most cases, it is very obvious that plants have no sensation or voluntary motion, yet there are some which seem to form an exception. Thus, the branches and leaves of all plants direct themselves toward the light. Certain plants, at the approach of night, or in gloomy weather, close their leaves and flowers; and there are some, as the Sensitive Plant, that shrink, as it were, on being touched. An American marsh-plant, Venus's Fly-trap, has its leaves terminated by an appendage of two lobes, furnished with long spines on the edges, and in the centre of this appendage a space which secretes a fluid attractive to flies. Should an insect alight on this space, the lobes instantly close, and the animal, pressed against the sharp points on the secreting disk, is soon put to death. The plant named Sun-dew has its leaves bordered with hairs, the tips of which are often seen covered with a drop of clear clammy fluid, and which, on being irritated, immediately fall down. If the lower part of the stamens of the common Barberry be touched, they will spring against the pistil or central organ of the flower. But these phenomena differ from the voluntary motion of animals, and are explained on mechanical principles.

4. *Analogies of Plants and Animals.*—But although plants differ in many respects from animals, they agree in others. Thus both are produced from a germ or egg, increased by the assimilation of foreign matter, attain their full development, propagate their species, decline, lose their vitality, and, being reduced to the condition of

inorganic matter, become subject to the decomposing influence of the atmospheric agents, and are ultimately dispersed, so that their elementary particles are free to enter into new combinations. Plants, as well as animals, respire air, and have a continual motion of their fluids, which are partly converted into solid matter, and partly dispersed by passing through the pores of the superficial parts. They are equally composed of solids and fluids; and the former are disposed in the forms of membranes, cellules, and tubes. These analogies, however, are far from being close, and the organs of plants are not, without great latitude, comparable to those of animals. Opportunities of pointing out affinities will occur, when we treat of the structure and functions of the different parts of vegetables.

5. *Divisions of the Subject.*—The study of Botany admits of a fourfold division:—1. *Structural Botany* comprises the laws of vegetable structure, or organography; this is internal or external, and it is independent of the presence of a living principle. 2. *Physiological Botany* relates to the living functions of plants, and their modifications in conditions of health and of disease. 3. *Descriptive Botany* embraces the description and nomenclature of plants. 4. *Systematic Botany* is devoted to the principles by which plants are associated with, or distinguished from, one another.

RECAPITULATION.

1. Define a Plant. Does a general definition afford a precise idea of the nature of plants? Why does it not? Are some plants extremely unlike others? Are there many organs common to all plants? 2. What difference is there in the mode of nutrition of plants and animals? Why should the motion of the fluids depend on internal agents in animals, and on external in plants? What differences exist in respect

to chemical composition? Have plants nerves and muscles? Are they destitute of a heart and vessels analogous to arteries and veins? 3. Mention some examples of apparent motion in plants. Upon what does it depend? 4. What are some of the analogies between plants and animals? 5. What divisions of the subject are usually adopted?

CHAPTER II.

ELEMENTARY PARTS OF PLANTS.

GENERAL ACCOUNT OF THE ORGANS OF PLANTS. THEIR INTERNAL STRUCTURE. CELLULAR AND VASCULAR TISSUE, WITH THEIR MODIFICATIONS.

6. *Organs of Plants.*—The parts of which a plant is composed are named its *Organs.* Thus, the root, the stem, the leaves, the petals, are organs, that is, parts distinguishable from each other by position, form, structure, and function. These organs are composed of *Elementary parts,* differing from one another, but so minute as generally to be distinctly visible only with the aid of the microscope. These minute parts are named *Elementary Organs, Organic Tissue,* or *Vegetable Tissue.* The organs of plants, properly so called, or those visible externally, and forming conspicuous and readily distinguishable parts of plants, are physiologically divided into two kinds; namely, the *nutritive* or *conservative* organs, or those subservient to the development and preservation of the individual; and the *reproductive* organs, or those which have reference to the continuation of the species.

7. *Nutritive or Conservative Organs.*—The Root, the Stem, the Branches, the Leaves, and some other parts, are those by which the function of nutrition is performed.

It is by means of them that the plant imbibes air and moisture, circulates its juices, subjects them to the action of the air, converts them into solid matter, and throws off the superfluous or useless parts. In very many plants, these organs may be arranged into two series, the *ascending*, and the *descending*, although the distinction is not of much use. The root and its parts, having a tendency to shoot downwards into the earth, belong to the former; while the stem, which shoots upwards, the leaves, flowers, and other parts, are referred to the latter.

8. *Reproductive Organs.*—The various parts forming the Flower and the Fruit, constitute the organs destined for the continuation of the species. The flower includes various parts—an outer envelope, named the Calyx; an inner envelope, named the Corolla; certain bodies named the Stamens, and a central body named the Pistil. This last, when fully developed, constitutes the Fruit, which is divisible into several parts. These organs are at present merely alluded to, introductorily to the subject, for the examination of their structure must be preceded by that of the elementary tissue of which they are composed.

9. *Internal Structure.*—The minute particles of matter of which plants are composed, are combined or united in such a manner as to form two modifications of structure. If we take any common plant, and cut its stem across, we perceive that it is composed of a spongy or cellular mass, denser in some parts, and presenting larger apertures in others. If we cut the same stem longitudinally, we find the cells assume a different appearance, being elongated, and in some parts like fibres or tubes. Applying the microscope to the transverse section, (Fig. 1, *a*), we find its cellules arranged like a network, in the midst of which are the larger openings. In the longitudinal section, (Fig. 1, *b*), the network is seen to be formed of more or less elongated cells, while the large apertures

seen in the transverse section are found to belong to cylindrical tubes. Different plants present different ap-

(Fig. 1.)

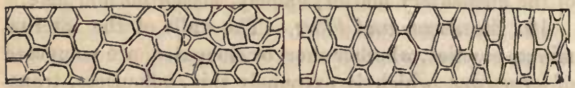
pearances, and in some there are none of those cylindrical fibres or tubes. But the conclusion to which we come is, that plants in general are composed of angular cells and cylindrical tubes, arranged so as to be more or less elongated in the direction of the axis of the stem or other organs. If we examine the cells and tubes more minutely, we find them to be formed of two kinds or modifications of the elementary matter, namely, *membrane* and *fibre.*

10. *Membrane and Fibre.*—The walls of the internal minute cavities, whether short or elongated, are composed of *membrane,* which is extremely thin, colourless, transparent, and generally tears equally in every direction. It is destitute of visible pores or perforations, although, from the passage of liquids through it, we cannot but suppose that apertures of some kind exist in it. *Fibre,* as here considered, does not constitute the elongated cells or fibres of plants, but is an extremely attenuated form of the elementary substance, which is sometimes straight, but usually spiral, or tortuous. Many observers allege that it is hollow, while others consider it as solid. Of these two elementary textures, Membrane and Fibre, all the organs of plants are composed. The forms under which they exhibit themselves are:—Cellular Tissue and Vascular Tissue.

11. *Cellular Tissue.*—The general appearance of the *Cellular Tissue* may be compared to that of froth obtained by blowing bubbles in soap-water; but the cellules or

vesicles, of which it is composed, assume many forms. The pith of plants is entirely composed of it, but it also enters largely into the structure of the other parts, and in many is the only tissue. It is always transparent and colourless, for, although it presents a vast diversity of colours, and, in fact, is the seat of colour in all parts of plants, this is owing to the colouring matter of various kinds which it contains. This colouring matter is frequently fluid, but often composed of granules adhering to the walls of the cells or immersed in liquid. The most common appearance of the cellular tissue is that of a multitude of spheroidal cellules, rendered more or less angular by being compressed. Frequently in the transverse section of a plant, (Fig. 2, *a*), they present an irregularly

(Fig. 2.)



a *b*

hexagonal form, resembling that of honeycomb. In the longitudinal section, *b*, each cell exhibits, more or less perfectly, the form presented by the vertical section of the geometrical solid called the dodecahedron. Their walls are destitute of visible pores, but generally allow a transfusion of fluid from one cell to another. Although always very small, the cellules vary exceedingly in dimensions, the largest being in diameter about the 20th part of an inch, the smallest not more than the 1000dth. They often leave vacuities between them, which are named *Intercellular Passages.*

12. *Varieties of Cellular Tissue.*—Two kinds of Cellular Tissue may be distinguished; the Common, and the Ligneous, the latter being of a denser texture, and composed of more elongated cells. Another division is into

Membranous and Fibrous. The *Membranous* Cellular Tissue, or that in which the walls of the cellules are composed solely of membrane, is the more common kind, and may be considered as the basis of the vegetable structure, it being never wanting in plants, while many are entirely composed of it. The cellules of this variety may be globular, (Fig. 3, *a*); oblong, *b*; cubical, *c*; muri-

(Fig. 3.)

form, or resembling the bricks in a wall, *d*; prismatic, *e*; elongated, *f*; fusiform or spindle-shaped and dotted, *g*; or irregular, *h*. The *Fibrous Cellular Tissue* is of two kinds, being composed either of membrane and fibre combined, or of fibre alone. Of both kinds there are several modifications, but it will suffice here to mention a few of those of the former. Sometimes an oblong cell has a fibre spirally twisted round it, (Fig. 4, *a*); or the fibre

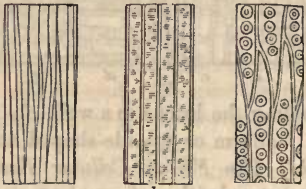
(Fig. 4.)

may anastomose irregularly, *b*; or the cell may have a reticulated appearance, produced as it were by two fibres crossing each other, *c*; or the fibres may be longitudinal and parallel, *d*.

13. *Woody Cellular Tissue.*—This is also named *Woody Fibre*, it having at one time been supposed to consist of fibres infinitely divisible. It is, however, merely a modification of cellular tissue, in which the cells are much

elongated, generally pointed at both ends, and although lying close together in bundles, having no direct communication with each other. This kind of tissue is possessed of great tenacity, and is chiefly that employed in the manufacture of thread and cords, the fibres of flax, hemp, and phormium being composed of it. In the woody parts of plants three varieties have been observed. In one, (Fig. 5, *a*), the walls are even; in another, *b*, they

(Fig. 5.)

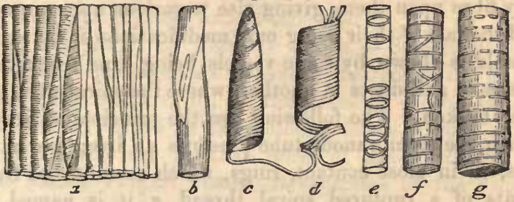


present, adhering to them, scattered granules; and in the third, *c*, the walls have regular series of circular glandules, having an opaque centre. This last kind is peculiar to the trees named Coniferæ, such as the Firs, Pines, and Junipers.

14. *Vascular Tissue.*—The vessels of plants have little resemblance to the blood-vessels of animals, which are branched and anastomose, or unite with each other. Vegetable Vascular Tissue, on the contrary, is composed of very elongated membranous tubes, tapering at each end, and having a spiral fibre within them, or having their walls marked with broken spiral lines, or dots arranged in a circular or spiral direction, (Fig. 6, *a*, *b*, *c*, *d*). The vessels of plants, in fact, might be considered merely as modifications of the common cellular tissue. They are represented by some as having a communicating aperture at their junction *b*, while others find no pore or perforation in them. Two principal kinds of vessels are dis-

tinguished, namely, *Spiral Vessels,* and *Ducts,* which, however, show intermediate gradations.

(Fig. 6.)



15. *Spiral Vessels.*—A membranous tube, tapering to a point at each end, and having within it a cylindrical fibre spirally rolled, and capable of being untwisted, is the variety of elementary cellule to which the name of *spiral vessel* is given, *c, d.* From a fancied resemblance in form and function to the windpipe of an animal, it also frequently obtains the name of *Trachea.* Some have considered this kind of vessel as formed of a fibre spirally twisted, without any membrane, while others state that it is composed of a fibre rolled round or within a cylindrical membrane. The fibre also has been variously represented as cylindrical, flat, or tubular. A spiral vessel may be formed of a single thread or fibre, *c,* or of two or any number up to twenty, *d.* In the former case, it is said to be simple, in the latter compound. These vessels are extremely delicate, their diameter averaging the 1000dth of an inch. They are very seldom found in the root, bark, or wood, but are frequently abundant in the other parts. They are easily discovered on breaking asunder the leaves and stalks of many plants, as of the Strawberry, the Dogwood, &c., when they unroll, and present themselves as delicate filaments like those of spiders.

16. *Ducts.*—All the varieties of vessels not furnished

with an elastic spiral filament are named *Ducts.* The fact of these vessels being merely elongated cellules is manifested by the analogous ramification of the elementary fibre upon them, giving rise to various appearances; and the fact of their being only modifications of the spiral vessels is shown by some vessels being true tracheæ in one part, and ducts in another, where the spiral fibre has been broken. The following are the principal varieties. When the membranous tube presents at irregular intervals, or in close contact, rings, which seem to be fragments of a ruptured spiral thread, *e,* it is named an *Annular Duct.* When the spiral fibre is in some parts continuous, in others branched and anastomosing, and sometimes presents the appearance of bars, (Fig 6, *f*), the vessel is named a *Reticulated Duct.* The *Dotted Duct, g,* is that in which the fibre has been broken into small and nearly equal fragments. Ducts are generally much larger than true spiral vessels, many of them being distinctly visible to the naked eye, and some so large as to admit a hair.

Pl. I., Fig. 1, is a highly magnified representation of the tissue of plants, in a longitudinal section: *a a a,* being cellular texture; *b,* continuous woody fibre; *c,* dotted woody fibre; *d d d,* ducts of various kinds; *e e,* spiral vessels.

Besides these elementary organs, properly so called, there are various cavities resulting from their mode of connection or separation, which require notice.

17. *Vacuities in the Tissue.*—As already mentioned, the cellules often leave between them vacuities, to which the name of *Intercellular Passages* is given, and which always contain a fluid. They vary in size, being large in succulent plants. Besides these passages, there are often in plants vacuities or *Lacunæ* in the tissue, which are bounded by its cellules, and although usually of irre-

gular form, are sometimes very uniform. They have no lining membrane, but do not communicate with the intercellular passages; they contain air, on which account they are appropriately named *Air-cells.*

18. *Receptacles of Peculiar Juices.*—Sometimes the intercellular passages are unusually dilated by the fluids which they contain; or, by the pressure of the latter, cavities are formed in the cellular tissue. Such cavities, filled with the peculiar juices of the plant, are by some named *Proper Vessels*, Receptacles of the Juice, Reservoirs of the proper or peculiar fluids, or Accidental Reservoirs. Although destitute of lining membrane, their walls are generally compact, being formed of condensed cellules. They vary in size and form; and, although often very regular, sometimes have no definite figure or arrangement.

Remarks.—Of these modifications of membrane and fibre are formed all the parts of plants. The varied combinations of the vascular and cellular tissues give rise to an endless variety of structure and external form, and produce an equal diversity in the properties of the juices and secretions. Many plants are entirely composed of cellules, but the greater number consist of both cellules and vessels. These elementary parts form certain compound organs, which will be described in the next chapter.

RECAPITULATION.

6. What is meant by the term Organ? Of what are organs composed? How are the organs divided? 7. Give an account of the Conservative Organs. 8. What are the Reproductive Organs? 9 How many kinds of Elementary Structure are there? What is observed in the transverse and longitudinal sections of a common plant? 10. What is meant by Membrane? In what respects is Fibre different?

11. What does Cellular Tissue resemble? What are its properties? Describe its general appearance. Are its walls pervious, or porous? 12. How many kinds of cellular tissue are there? Give an account of membranous cellular tissue. Describe the fibrous variety. 13. Of what nature is woody cellular tissue? How many varieties of it are usually described? How are they distinguished? 14. Define Vascular Tissue. What are its two principal kinds? 15. Give a general account of the Spiral Vessels. 16. In what respects do ducts differ? Describe their three varieties. 17. What kinds of vacuities occur in the tissue of plants? 18. What is the nature of the receptacles of the peculiar juices of plants?

CHAPTER III.

GENERAL INTEGUMENT OF PLANTS, AND PARTS CONNECTED WITH IT.

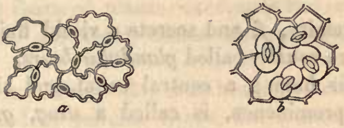
19. *Epidermis.*—The tissue, or intimate structure, of all plants is composed of the elementary parts described in the preceding chapter; but there are parts more or less complex, which may also be considered as elementary. These are the Cuticle or general envelope of plants, and the various organs immediately connected with it.

The *Epidermis* or *Cuticle* is the delicate membrane which invests almost all the organs of plants. It has been so named on account of its analogy, as to position at least, with the Cuticle or Scarf-skin of animals. Plants, however, have not a true cutis or skin, and their cuticle is in many respects different from that of animals. The Epidermis presents the appearance of a transparent pellicle, but, when examined with the microscope, it is found

to be composed of three distinct parts. The outermost layer is an extremely delicate film, homogeneous in its structure, and perforated by minute oblong pores. Under it is a layer of flattened cellules, sometimes arranged in two or three series. The other element of the cuticle consists of the organs named stomata.

20. *Stomata.*—A stoma is an aperture in the cuticle, laterally bounded by two generally curved vesicles,

(Fig. 7.)



(Fig. 7, *a*, *b*). Some observers, however, deny the existence of any opening in the stomata, which they consider as cutaneous glands. But the general opinion is that they are pores, which are capable of being closed by the enlargement or elongation of the two cellules forming their sides. They vary in form, being sometimes square, sometimes oblong or circular. It is commonly supposed that they are subservient to transpiration, and are connected with the reticulated tubes lying in or under the epidermis. In many tribes of flowerless plants, and in the parts of aquatic plants that are under water, they are not found.

21. *Hairs.*—On the cuticle are observed various prolongations resembling hairs or bristles, which are composed of cellules, generally elongated, and disposed in a single series. Sometimes these hairs are composed each of a single cellule, (Fig. 8, *a*); more frequently of several cellules, *b*; in which case they have the appearance of a tube divided by transverse partitions. They may be branched, *c*, or covered with small processes, which are themselves also sometimes branched, *d*, or they may be

divided in a stellular manner, *e*. Hairs are generally acute, *a*, *b*, but often they end obtusely, or are enlarged

(Fig. 8.)

at the extremity, *f*, and secrete a viscid fluid. In this case they are usually called *glandular hairs*. A tapering pointed hair having a central canal, and situated on a glandular prominence, is called a *sting*, *g*, as in the Nettle; such hairs are analogous to the poison-fangs of serpents. Considered in a general sense, hairs constitute what is called the *Pubescence*, of which various kinds are described. Thus the surface of a plant is said to be *downy*, when the hairs are short, delicate, and flexuous; *villous*, when long, straight, and soft; *pilose*, when long, scattered, and rather soft; *hirsute*, when rather long and stiff; *tomentose*, when longish, soft, entangled, and pressed close to the surface; *silky*, when long, very slender, closely pressed, and glistening; *ciliated*, when arranged along the margin of an organ, like cilia or eye-lashes; *bearded*, when long and tufty; *bristly*, when conical, short, and stiff; *hispid*, when conical, long, and stiff. Hairs are not found on true roots, nor on any part of the stem placed underground, nor on parts immersed in water. They may occur on any other part of the surface of a plant, however, as well as in its cavities.

22. *Prickles.*—These organs may be considered as complex rigid hairs, (Fig. 9, *a*). They are of a conical form, straight or curved, and are composed of cellular tissue. Being attached only to the bark, they are easily

distinguished from spines, which are abortive branches, or prolongations of the woody tissue. Prickles, *Aculei*,

(Fig. 9)

occur on all parts of plants, excepting the organs called stamens, but are rarely found elsewhere than on the stem.

23. *Scales.*—Thin, flat, membranous, scurf-like processes formed of cellular tissue, are named *Scales*, and differ from hairs chiefly in being more compound, and not of a cylindrical or tapering form, (Fig. 9, *b*). This kind of scale is also named *Lepis*, and is to be distinguished from another, which is a kind of rudimentary leaf, or *squama*. *Ramenta*, (Fig. 9, *c*), are thin, brownish scales, composed entirely of cellular tissue, and distinguished from leaves by the absence of buds in their axillæ. Of this kind are the scales so abundant on the stalks, and leaves of Ferns.

24. *Glands.*—By the term *Gland*, or *Glandula*, is designated a small, more or less dense, prominence in the tissue immediately beneath the cuticle, which it causes to project, (Fig. 9, *d*). *Warts*, or *Verrucæ*, are roundish glandules, filled with opaque matter, which, when numerous, give the surface a kind of roughness designated by the term *scabrous*. Glands may be *sessile*, or *stalked*. In the former case, they present the appearance of roundish, conical, or cylindrical bodies; in the latter, they are roundish bodies, secreting some peculiar fluid, and elevated upon a stalk.

RECAPITULATION.

19. What is the nature of the Epidermis or Cuticle? Of how many parts is it composed? 20. Describe the Stoma. Is it of general occurrence? 21. What is meant by a Hair? What are the principal varieties of hairs? What is the Pubescence? Mention some of the kinds of surface produced by varieties of pubescence. 22. What are Prickles? 23. Define Scales. What other organs have been so named? 24. What are Glands?

CHAPTER IV.

COMPOUND ORGANS OF PLANTS.

GENERAL VIEW OF THE ARRANGEMENT OF PLANTS FOUNDED UPON THEIR STRUCTURE.

25. *Organs of Plants.*—The Elementary Organs, the nature of which is disclosed by minute examination, with the aid of the Microscope, combine in various manners to form the parts of plants to which we give the name of Compound Organs, or simply of Organs, and which have already been mentioned as divisible into two kinds, Organs of Nutrition, and Organs of Reproduction. These organs do not all exist in every species of plant, nor in any species do they shew themselves all at once, but are successively developed, and sometimes are transformed into one another. To obtain a general idea of them, it will therefore be expedient to follow the progress of growth in a common plant, from the period at which the seed begins to germinate, to that at which it produces a seed like itself.

26. *Rudimentary Organs.*—In every seed is contained within the general envelopes a small organized body, which is named the *Embryo,* Pl. I., Fig. 4, *f, g.* When germination has commenced, this body swells, bursts the envelopes, and shoots out into two parts, one of which proceeds downwards into the ground, while the other ascends into the air. The descending part, *f,* which is named the *Radicle,* ultimately becomes the *Root.* The ascending part, *g,* the *Plumule* or *Caulicle,* is the rudiment of the *Stem,* leaves, and flowers. The point of junction of the plumule and radicle, is the *Neck* or *Life-knot,* and from it proceed laterally one or more appendages, which are named *Cotyledons* or *Seminal Leaves,* Pl. II., Fig. 7, they being in fact parts which become the first leaves of the plant. In this stage those parts may be called rudimentary organs.

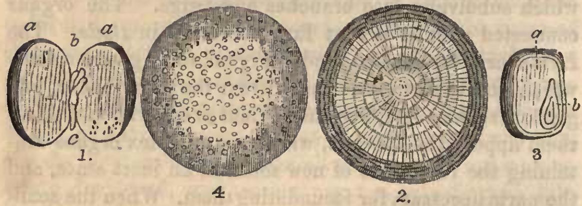
27. *Perfected Organs.*—When the *Root,* Pl. II., Fig. 7, has attained its full growth, it usually presents a fleshy body, variously branched, and furnished with *Fibrils* or *Radicles,* having at their extremity a small spongy body, by which nourishment is extracted from the soil. The plumule, on becoming developed, shoots up into a *Stem,* which subdivides into branches and twigs. The organs connected with it are at first contained in *Buds.* The *Leaves* are flattened expanded organs of a green colour, which absorb nutritious fluids from the atmosphere, and give out such as have become noxious or superfluous. After them appear the *Flowers,* which are complex organs containing the rudiments of new seeds in an inert state, and the parts necessary for fecundating them. When the seminal germs have been vivified, the flower withers, with the exception of the part containing the seeds, which continues to grow, and constitutes the *Fruit.* Thus, the essential or fundamental organs of plants may be reduced to five, of which three, the Root, the Stem, and the Leaves,

being subservient to the growth and preservation of the individual, are named Organs of Nutrition; while the remaining two, the Flower and the Fruit, being subservient to the continuation of the species, are the Organs of Reproduction. These organs come now to be examined in succession; but preparatorily to their inspection, it becomes expedient to enter into a short exposition of some circumstances, which must frequently be alluded to in the course of our descriptions.

28. *General Idea of Classification.*—All the *individual plants* that correspond with each other in all their parts, and have been derived from one common stock, constitute *species.* Species agreeing closely together in their more important features, form *genera.* The genera are variously grouped into *tribes, families, and orders;* but all these groups ultimately arrange themselves into three comprehensive groups, named *Dicotyledons, Monocotyledons,* and *Acotyledons.*

29. *Characters of Dicotyledons.* — The seeds of this great class of plants are composed of two fleshy bodies, named *Cotyledons,* (Fig. 10, 1), *a a,* and the *Embryo,*

(Fig. 10.)



b c, or essential rudiment of the future plant, already described. It is the circumstance of there being *two* cotyledons that gives the name to the group. The stem also presents peculiarities, by which it may be easily distinguished, (Fig. 10, 2). When young, it has in the centre

a cylindrical mass of cellular tissue, named the *Pith.* This is surrounded by a layer of vascular tissue, named the *Medullary Sheath.* The external part or envelope is the *Epidermis.* Between the medullary sheath and the epidermis is formed a mass of vascular and cellular tissue, which at length separates into two parts, the inner forming a layer of *Wood,* the outer a layer of *Bark.* At the end of the second year, between the wood and the bark is found a new double layer of wood and bark. In the third year, there are three layers of wood, and three layers of bark; and in this manner the stem increases in thickness, year after year. In a transverse section of such a stem there are seen the central pith, several concentric rings of wood, an equal number of thinner and usually confused layers of bark, together with bands of cellular tissue radiating from the pith to the bark, and named *Medullary Rays.* The existence of two cotyledons in the seed, of successive layers of wood and bark, and of medullary rays, characterize this class of plants, which are also named *Exogenous,* from the circumstance of their stems enlarging by the apposition of new layers of wood *externally* to those already formed.

30. *Character of Monocotyledons.*—In this class, the seed, (Fig. 10, 3), is chiefly composed of a mass of albuminous matter, *a,* inclosing the embryo, *b,* which, in germinating, pushes upward, and ultimately perforates the *single* conical cotyledon. In the stem, (Fig. 10, 4), there is no distinction of parts into pith, wood, and bark, it being a cylindrical mass of cellular tissue, in which are dispersed bundles of vessels. The addition of new matter is made towards the centre, and the outer parts are harder than the inner. In consequence of this peculiarity in the mode of growth of the stem, these plants are also called *Endogenous.*

31. *Characters of Acotyledons.*—The plants of which

this great class is composed are destitute of seeds, properly so called, and consequently have *no* cotyledons; whence their name. From their not having spiral vessels in their structure, they being formed either of cellular tissue alone, or of cellular tissue and ducts, they are also named *Cellulares.* Their reproductive organs, which are termed *Sporules*, are minute granular bodies, having no distinct parts, but germinating by the increase of cellular tissue. This class is divided into several orders; Ferns, Equisetaceæ, Lycopodiaceæ, Mosses, Hepaticæ, Lichens, Fungi, and Algæ.

The Acotyledons being destitute of flowers, are also named *Flowerless* or *Cryptogamous* Plants; while the Monocotyledons and Dicotyledons, being furnished with these organs, are named *Phanerogamous* or *Phœnogamous.* Botany, in fact, is encumbered with superfluous terms.

These preliminary explanations being made, we may now proceed to examine the five principal organs, with their modifications and appendages.

Recapitulation.

25. Of what are the Organs of plants composed? 26. Mention the parts observed in a germinating Seed. 27. What are the five principal organs of a perfect plant? 28. Into what three classes may all plants be arranged? 29. Describe the seed of a Dicotyledonous plant. What parts are observed in its stem? What appearance is presented by a transverse section of it? 30. In what respects do the Monocotyledons differ? 31. What are the general characters of the Acotyledons? What is meant by Exogenous and Endogenous; by Phanerogamous and Cryptogamous?

CHAPTER V.

FORM AND STRUCTURE OF THE ROOT.

32. *General Idea of the Root.*—The organs of nutrition, or those subservient to the growth and preservation of the individual, are the Root, the Stem, and the Leaves. Those intended for the continuation of the species are the Flower and the Fruit. Many authors divide a plant into two parts, the *Descending Body*, and the *Ascending Body*, the former composed of the Root, the latter of the other organs. The ROOT, Pl. II., Fig. 7, may be defined that part which terminates the plant below, and penetrates into the soil. It thus fixes the plant in a commodious situation, and extracts nutritious matter from the earth for its support. It generally consists of two parts, the *Caudex* or body, and the *Radicles* or fibres. Its upper part, from which spring the stem and the leaves, being frequently narrowed, is named the *Neck*. The radicles are the only essential parts of the root, it being by their usually spongy extremities that moisture is absorbed. Many botanists have considered as roots all those parts of a plant which are immersed in the soil; but, in so doing, they have sometimes confounded the stem with the root. Thus, what they call a creeping root, Pl. II., Fig. 6, as in Mint, is merely a subterranean part of the stem. Although the root is usually fixed in the ground, there are plants which, floating on the water, send out radicles which never reach the bottom; and in tropical countries there are flowering plants which grow upon trees, into the bark of which their roots are inserted.

33. *Structure of the Root.*—A root of the ordinary kind, in Dicotyledonous plants, consists of cellular and

vascular tissue, but without spiral vessels, and, like the stem, is divisible into a central part, in which, however, are no pith or concentric circles, although there are radiating plates of cellular tissue, named medullary rays; and a cortical part, analogous to the bark. This arrangement may be seen in the Carrot, of which the outer red portion is the bark. The cuticle, or epidermis, differs from that of the skin in having no stomata. The lower part generally divides into branches, these into subordinate divisions, terminated by small bodies, composed of cellular tissue, without epidermis, and named *Spongioles*. It is remarkable that the root never has a green colour, unless after being for some time exposed to the air.

34. *Position of the Root.*—Although the root usually terminates the plant below, the stem and branches may, by the application of moisture, and by being kept in the shade, be made to give off roots. As an example of this may be adduced the celebrated Banyan tree of India, the horizontal branches of which send down roots, which, fixing themselves in the ground, are ultimately converted into stems, and, continuing to enlarge, form gigantic props. The rooting of the Mangrove is very peculiar: it consists, not, as in ordinary trees, of subterranean, but of aërial divisions of the stem, forming numerous arches, and thus affording a large base by which the tree secures a firm hold in the loose and swampy soil in which it grows. Captain Basil Hall describes a forest of Mangroves, which had so encroached, by their remarkable mode of rooting, upon the sea, that pioneers in boats were obliged to clear a way for the traveller to proceed.

35. *Duration and Texture.*—Some plants continuing only for a single year, or a single season, have *annual* roots. Other plants require two years for their full development, and thus have *biennial* roots. *Perennial*, or

lasting roots, are those of woody plants, or of soft plants which die down to the ground annually, but shoot up, year after year, their roots remaining alive. Annual and biennial roots are generally of a soft and more or less succulent texture, as are those of many perennial plants; but the roots of trees and shrubs are, like themselves, hard and woody.

36. *Principal kinds of Root.*—There is great diversity in the form of the root; but the principal modifications, or those more commonly observed, are the following:—

The *Fibrous Root. Radix fibrosa.* Pl. II., Fig. 5. This kind of root consists of a great number of fibres or filaments, which are sometimes simple or unbranched, at other times variously subdivided. The fibrous root is that seen in monocotyledonous plants, and is commonly considered as that of all annual plants. But in many of these, although slender, it presents exactly the same form and structure as the Tapering Root. The fibres of the roots of most grasses that grow in dry sandy soil are remarkably downy; and those of grasses growing in very moist situations are covered with similar prolongations, though much thicker. The protecting power of these plants in fixing sand-banks is remarkable: the sand-hills on the French coast, between Dunkirk and

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Description of Plate II.—Fig. 5. Fibrous Root of a grass. Fig. 6. Creeping Root-stem of Mint. Fig. 7. Fusiform or Tapering Root of a Radish, with the two cotyledons, and young leaves. Fig. 8. Abrupt Root of *Scabiosa succisa.* Fig. 9. Tuber. Fig. 10. Oval Lobes of an *Orchis.* Fig. 11. Palmate Lobes of an *Orchis.* Fig. 12. Digitate Lobes of an *Orchis.* Fig. 13. Cormus of *Crocus.* Fig. 14. Tunicate Bulb of *Allium.* Fig. 15. Scaly Bulb of *Lilium.* Fig. 16. Granulated Root of *Saxifraga granulata.*

Boulogne, especially about Calais, are covered with mat-grasses, which keep them firm, and the banks on our Flintshire shores, in the parish of Llanissa, are similarly fortified. In what is called the Creeping Root, Pl. II., Fig. 6, the fibres alone are the roots.

37. The *Tapering Root. Radix fusiformis.* Pl. II., Fig. 7. This root, named also *conical* and *perpendicular*, or *vertical*, is generally fleshy, and of an elongated conical form, either simple, that is, undivided, or branched at its lower extremity. The most common example is afforded by the garden Carrot. In the Radish it is spindle-shaped, or tapering toward both ends. When slender and much branched, as in trees and shrubs, as well as in many herbaceous plants, it is usually confounded with the fibrous root, which, however, is peculiar to monocotyledonous plants. By tracing through their gradations the numberless varieties of the cultivated Turnip, it will be seen that its "bulbs" are merely modifications of the conical root. Another remarkable variety is that to which the name of *Radix præmorsa, Abrupt Root,* has been given, Pl. II., Fig. 8. This is, in fact, a tapering root, of which the lower or descending part has decayed, so that it seems as if bitten off. A common example of it is seen in *Scabiosa succisa,* the *Devil's-bit Scabious,* respecting which the old opinion, as expressed by Gerarde, was as follows:—"The great part of the root seemeth to be bitten away: old fantastick charmers report, that the divel did bite it for envie, because it is an herbe that hath so many good vertues, and is so beneficial to mankinde."

38. The *Tuberiferous Root. Radix tuberifera.* Pl. II. Fig. 9. Although most roots may be considered as modifications of the Fibrous and the Tapering, many present remarkable appendages, and require to be separately considered. Thus, the *Tuberiferous* Root is a

fibrous root, to which are attached fleshy or amylaceous knobs or tubers, which, being furnished with buds, are considered as a kind of subterranean stems, and will be afterwards spoken of. A familiar example is the Potato. If the term *Tuber* be appropriated to the potato, and similar subterranean productions furnished with buds, it becomes necessary to apply another to those fleshy bodies, which are merely reservoirs of nutritious matter. Professor Lindley proposes naming them *pseudo-tubers*, or false or spurious tubers; but as they are neither tubers, nor yet in any respect spurious, I think they may rather be named Lobes.

39. The *Lobiferous Root. Radix lobifera.* Pl. II., Figs. 10, 11, 12. A fibrous root, having attached to it, or connected with it, one or more masses, or lobes, of cellular tissue, charged with amylaceous matter, and intended as reservoirs for the future development of the plant, is termed *lobiferous*. Lobes of this kind are seen in Orchideous plants, and are of various forms. Thus, they are *oblong* or *ovate* in *Orchis mascula*, (Fig. 10); *palmate*, or shaped like a hand, as in *Orchis latifolia*, (Fig. 11); *digitate*, or finger-like, as in *Satyrium albidum*, (Fig. 12). They are extremely numerous and irregularly branched in *Corallorrhiza*.

40. The *Bulbiferous Root. Radix bulbifera.* Pl. II., Figs. 14, 15. This is a fibrous root, surmounted by a fleshy body named the *Disk*, which supports a *Bulb*, or peculiar kind of bud, to be afterwards described. It is only from vaguely considering all subterranean parts as roots, that the bulb, lobe, and tuber, have been mistaken for roots. Pl. II., Fig. 14, Tunicate Bulk of *Allium*; (Fig. 15), Scaly Bulb of *Lilium*.

41. The *Granuliferous Root. Radix granulifera.* Pl. II., Fig. 16. When a great many small lobes, having an eye or bud, and consisting of fleshy scales,

grow in clusters, and are scattered on the fibres of the root, the latter is said to be *granulated,* as in a very common plant, *Saxifraga granulata.*

42. The *Fasciculate Root* consists of a *fasciculus,* or bundle of slender fleshy bodies, issuing from the neck of the plant, as in Dahlia.

43. *Direction of the Root.*—The root may be *vertical,* as in the Carrot and Parsnip; *oblique;* or *horizontal.* Frequently all these directions may be found in the same root. The extent to which roots spread depends chiefly on the nature of the soil: but in large trees, the roots being frequently unable to penetrate deeply into the hard subsoil, assume a great lateral extension, their extremities often passing far beyond those of the branches. Other circumstances relating to this subject will be mentioned in treating of the physiology of the root. It may be here remarked, that in *many plants,* belonging to the Acotyledonous series, the root does not exist as a distinct organ.

Recapitulation.

32. What are the organs of Nutrition? and of Reproduction? Define the Root. What are its parts? Is the root always fixed in the ground? 33. What is the structure of the root in dicotyledonous plants? Is it often green? 34. Does the root always proceed from the base of the stem? 35. How are roots named with reference to their duration? 36. Enumerate the principal varieties of the root. Describe the Fibrous Root. 37. What is a tapering or conical root? What changes of form does it present? What is a præmorse or abrupt root? 38. Why are some roots named tuberiferous? What is a tuber? 39. In what respect does a lobe differ from a tuber? 40. Describe the bulbiferous root? 41. What is meant by granuliferous? 42. What is the fasciculate root? 43. What are the three principal directions of the root?

CHAPTER VI.

FORM AND STRUCTURE OF THE STEM.

44. *General Idea of the Stem.*—The Stem may be defined that part of a plant, which, proceeding from the root, either extends under ground, or ascends into the air, and supports the leaves and flowers. Although all Phanerogamous plants are furnished with a stem, this is sometimes so short as to seem to be wanting, the leaves and flower-stalks appearing to spring from the top of the root. When this is the case, the plant is said to be *stemless, acaulis.* There are some kinds of flower-stalks, namely, the *Scape* and the *Radical Peduncle*, which, being conspicuous, are liable to be confounded with the stem, properly so called. On the other hand, there are stems, such as the *Rhizoma* and *Tuber*, § § 47, 49, which, being subterranean, have been mistaken for roots. These parts will presently be explained. In the meantime, let it be understood that the organ here considered as the stem is the ascending caudex of the plant, or that part to which the leaves, when there are any, are attached.

45. *Different kinds of Stem.*—The direction, form, texture, consistency, and clothing of stems, produce an almost endless variety in this organ, of which the principal kinds, however, may be reduced to eight. Of these, four are subterranean: the Cormus, Tuber, Rhizoma, and Creeping Stem; and four aërial: the Stem, Trunk, Stipe, and Culm.

46. The *Cormus.*—The *Cormus*, Pl. II., Fig. 13, is the enlarged base of the stem of certain monocotyledonous plants, forming the reproductive portion of such as are destitute of an aërial stem. It is developed under ground, and is of a roundish or oblong form. By many

botanists it has been described as a kind of root, or considered as a solid bulb. It consists of cellular tissue, with bundles of vessels and woody fibre. Examples are seen in the Crocus, Colchicum, and Arum.

47. *The Tuber.*—This kind of subterranean stem, often considered as a modification of the root, Pl. II., Fig. 9, may be defined an oblong or roundish body, of annual duration, composed chiefly of cellular tissue, with a great quantity of amylaceous matter, intended for the development of the stems or branches which are to spring from it, and of which the rudiments, in the form of buds, are irregularly distributed over its surface. The Tuber is thus not a root, but a kind of stem. Examples are seen in the Potato and Arrow-root. Nearly allied to it is the organ named the Lobe or Pseudo-tuber, in which there is only a single bud, § 38.

48. *The Creeping Stem.*—This kind of stem, *Soboles*, is that which many botanists have named the *Creeping Root*, Pl. II., Fig. 6. It is a subterranean stem, of a slender, elongated form, running nearly horizontally, emitting roots at intervals, and sending up shoots or new plants. The best examples of it are seen among the Grasses and Carices; for example, the Couch-Grass, *Triticum repens*, *Elymus arenarius*, *Triticum junceum*, and *Carex arenaria*, have stems of this kind, which, extending to a great length, and sending up shoots, while their radical fibres are numerous, and plentifully furnished with fibrils, serve to bind down the loose sand on the sea-shore, § 36.

49. *The Rootstock.*—The *Rhizoma* or *Rootstock* is a fleshy stem, varying in form, running horizontally under the surface, or partially protruded from it, and sending forth new stems at its anterior or upper extremity, while the other extremity gradually decays. Such a stem is easily distinguished from the root, by its increasing at the part nearest the leaves, and not by its lower end, by

its presenting traces of the leaves of preceding years, and by the appearance of buds upon it. A familiar example is seen in the Iris.

50. *The Stem.*—Although this is a general term for the ascending caudex, it is applied peculiarly to that kind of aërial stem, *Caulis*, which is of a soft or herbaceous nature, as distinguished from such as are hard or woody. It may be positively defined the ascending part of the plant which bears the leaves and flowers, and negatively that kind which is not a Cormus, Tuber, Creeping Stem, Rootstock, Trunk, Stipe, or Culm. It may vary in its direction from erect to prostrate; in form, from round to angular; in being simple or branched; in having its surface smooth or hairy; and in other circumstances.

51. *The Trunk.*—The *Trunk, Truncus,* is the woody stem of trees and shrubs, such as the Oak, Ash, and Hawthorn; and it is peculiar to dicotyledonous plants. It may be described as of an elongated conical form, its diameter being greatest at the base, and gradually becoming less towards the top. At its lower part, it is to a variable extent destitute of divisions, but towards its upper extremity it sends out *branches,* which divide into *twigs.* Internally, it is composed of concentric layers, varying in number, and disposed around its axis; and it increases in diameter by the annual addition of a woody layer, and a thinner layer of bark, at the part near the surface, where the wood and the bark are in contact. (Fig. 10, 2).

52. *The Stipe.*—The *Stipe, Stipes,* is the kind of woody stem peculiar to Monocotyledonous trees, and a few others. When destitute of branches, as it generally is, it presents the appearance of a slender column, being little thicker at the base than toward the top, frequently larger in the middle than elsewhere, and crowned by a

tuft of leaves and flowers. Internally, it has no appearance of concentric layers, and presents no distinction of wood and bark. It increases in thickness by the addition of fibres to its interior, and elongates by the development of the bud at its summit: of this kind are the stems of Palms. (Fig. 10, 4).

53. *The Culm.*—The *Culm* or *Straw, Culmus,* is the kind of stem peculiar to grasses, and plants nearly allied to them. It is generally simple or unbranched, fistulous, or having an internal cavity, and marked at intervals with joints or knots, formed by transverse partitions. The leaves are alternate, and at their base invest the stem with a kind of sheath. The culm, however, may be branched, or solid, or destitute of knots; so that a general character, including all its varieties, is not easily given; and many botanists have thought the distinction superfluous.

54. *Other varieties of Stem.*—Among the more remarkable kinds of stem not already enumerated, are the *Runner* and the *Sucker.* The former, *Sarmentum,* is a very slender prostrate stem or shoot, Pl. III., Fig. 22, at its extremity producing roots and a young plant, which, in like manner, sends out new runners. The most familiar example is that of the Strawberry. The *Sucker, Surculus,* is a branch which, proceeding from the neck of the root under ground, becomes erect on emerging, and produces leaves, flowers, and branches; as in many Roses. But it is unnecessary to specify all the varieties presented by the stem, and still less to give a name to each.

55. *Consistence of Stems.*—Plants are popularly distinguished, with reference to the consistence of their stems, into *herbs, shrubs,* and *trees.* 1. *Herbs,* or herbaceous plants have soft, green, annual stems, as chick-weed and groundsel. 2. *Shrubs,* or suffruticose or semi-lig-

neous plants, have stems of which the base is hard and endures for several years, while the extremities of the branches are soft and die annually, as lilac, sage, and thyme. 3. *Trees* have hard, woody, perennial stems, as the trunk of dicotyledons, and the stipe of palms. 4. Stems are further distinguished as *solid*, or destitute of internal cavity, as in the oak; *hollow*, or fistulous, as in reeds; *spongy*, or composed internally of loose, elastic, cellular tissue, as in typha; *succulent*, or juicy, when composed of a denser form of cellular tissue, filled with fluid, as in cactus. Various other terms are employed by botanists, the meanings of which are obvious, as *stiff*, *flexile*, *brittle*, &c.

56. *Branches.*—The divisions of the stem bear the general name of *branches*, or *rami*. The direction of young branches is generally upward; but as they increase in size, they assume more of a horizontal direction, from the effect of gravity, or from their effort to seek the light, when the upper branches have attained a certain size. The *angle of a branch* varies in different trees, but is pretty constant in each species, and affords marked characters: there is the very acute-angled, or *compressed* branch of the pyramidal poplar; the *divaricating* branches, which stand off at nearly right angles from the stem, *vis-à-vis* to each other; the *patent*, or irregularly spreading branches; and the *pendulous* branch of the Fraxinus excelsior. The last must be distinguished from the branch of the *weeping* willow, which becomes pendulous from weakness: the former are originally retroverted; the latter "weep" from the effect of gravity.

57. A stem destitute of branches is said to be *simple*, as in white lily; *alternately branched*, when the branches proceed alternately from the stem; *distichous*, or two-ranked, when they spread in two opposite directions, as in Silver Fir; four-ranked, or *brachiate*, when they spread in

four directions, in pairs which cross one another alternately, as in Lilac; forked, bifurcating, or *dichotomous*, when they occur in pairs which are regularly and repeatedly divided, with a flower-stalk springing from each division, as in Chlora, Pl. III., Fig. 17; *determinately branched*, when each branch, before terminating in a bud, sends off shoots in a circular form, as in Erica tetralix, *Azalea*, Pl. III., Fig. 23, &c.; *much branched*, when repeatedly divided into branches, without any definite order, as in the Apple and Gooseberry.

58. *Direction, form, appendages, and surface of the stem.*—1. With respect to its direction or mode of growth, the stem is *erect* or *prostrate; creeping*, when it lies on the ground, and sends down roots, as in Lysimachia nummularia; *trailing*, in the Strawberry; *clinging*, in the Ivy, Pl. III., Fig. 20; *climbing*, in the Vine. 2. As to its form, it is round or angular; two, three, or four, or five-sided; knotted or nodose; jointed, geniculate, &c. 3. The appendages of stems are usually leaves, but these organs are sometimes wanting, and they are replaced by large *scales*, as in Orobanche, Pl. III., Fig. 18; or the stem is *winged*, when it has flat leafy borders running along its angles, and formed by prolongations of leaves, Pl. IV., Fig. 36. 4. The surface is variously smooth or glabrous; mealy or farinaceous; glaucous, when the powdery matter constitutes a very fine layer,

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DESCRIPTION OF PLATE III.—Stems and Buds. Fig. 17. Forked stem of *Chlora perfoliata*. Fig. 18. Scaly stem of *Orobanche*. Fig. 19. Radicant stem of Ivy. Fig. 20. Twining from left to right, in *Lonicera*. Fig. 21. Twining from right to left, in *Convolvulus*. Fig. 22. *Sarmentum*, or Runner, of *Fragaria vesca*. Fig. 23. Stem determinately branched, in *Azalea*. Fig. 24. Three pairs of Buds, in *Lonicera cærulea*. Fig. 25. Bud of *Æsculus Hippocastanum*.

of a sea-green colour, and is easily removed, as in Chlora perfoliata; scabrous or rough; papillose, when covered with small tubercles; warty, when it presents small, roundish excrescences; dotted, spotted, streaked, grooved, corky, &c., terms sufficiently suggestive of their meaning. 5. By *pubescence*, is meant the down of plants, consisting of soft, short hairs, which partially cover the cuticle; it is described as downy, villous, pilose, hirsute, tomentose, silky, velvety, ciliated, and bristly. These terms will be found in the glossary at the end of the volume.

59. *Thorns.*—Some twigs, being imperfectly developed, lose their power of extension, assume a hard texture, terminate in a sharp point, and are then named *Thorns, Cuspides.* Sometimes they bear leaves, as in the Sloe and Hawthorn. Some trees, as the Pear and Sloe, which are naturally thorny, on being transplanted into a rich soil, lose their thorns, which, by the abundance of nourishment, are converted into leafy twigs. *Thorns,* Pl. IX., Fig. 120, must not be confounded with *Prickles,* Fig. 121. The former are continuous with the woody tissue of the plant, while the latter are merely attached to the surface. Thorns, in fact, are modified branches, while prickles are indurated hairs. Nor are they to be confounded with *Spines, Spinæ,* which, as will afterwards be explained, are metamorphosed leaves.

We now proceed to examine the internal or anatomical structure of the stem.

60. *Internal Structure of the Stem.*—If we take the stem of a herbaceous plant, such as the Field Scorpion-grass, *Myosotis arvensis;* that of a grass, such as the cultivated Wheat, *Triticum hibernum;* that of a common tree, such as the Ash, *Fraxinus excelsior;* and that of a Palm, such as *Corypha umbraculifera;* we find, on examining them, a diversity of structure, which shows

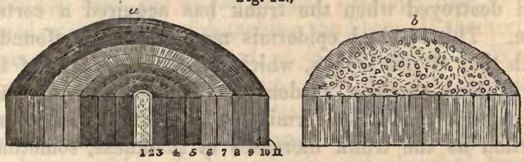
that we cannot refer to a single type the modifications which that organ presents. Although a general review of the whole vegetable kingdom, with respect to this subject, cannot be undertaken, it will suffice to afford a general idea of it, that we examine the stem of a tree belonging to the Dicotyledonous, and that of one taken from the Monocotyledonous series. The distinctive characters of these great series have already been briefly given in §§ 29, 30.

61. *Stem of Dicotyledonous Plants.*—A transverse section (Fig. 10, 2, p. 20) of the trunk of any of our common trees, an Ash, an Oak, or a Willow, presents two distinct parts, one of which, occupying the interior from the centre to near the circumference, is the *Wood,* or *Woody Body;* while the other, the *Bark,* or *Cortical Body,* is situated at the exterior, so as to envelope and enclose the wood. Each of these parts, the Wood and the Bark, is composed of two distinct portions, the one fibrous or vascular, the other cellular or parenchymatous. Of the Woody Body, the cellular part occupies the centre, where it forms a cylindrical column, which is named the *Pith* or *Internal Pith;* while the fibrous part, or *Wood,* is arranged in layers around the pith. In the Bark, on the other hand, the cellular part is placed at the exterior, where it forms a kind of parenchymatous covering to the whole plant, and is named the *Herbaceous Envelope,* or *Outer Pith;* while the fibrous part, or the *Bark,* is placed internally. The Woody Body, and the Cortical Body are thus two parts organized in an inverse direction, and which also increase in an inverse direction by annual layers, which are added to the exterior of the wood, but to the interior of the bark.

62. *Enumeration of the Parts observed.*—The preceding explanation affording only a general idea of the parts composing the stem of a tree, we may now examine

them somewhat more closely. In the centre is the *Pith* (Fig. 11, *a*, 1), a cylinder of cellular tissue, surrounded

Fig. 11.)



by the *Medullary Sheath*, 2. Proceeding outwards, we count five *Woody Layers*, 3, 4, 5, 6, 7; of which some of the inner, 3, 4, 5, are of a denser texture, and darker colour, than the outer, 6, 7; the former being collectively named the *Duramen* or *Heart Wood*, the latter the *Alburnum* or *Soft Wood*. In the Bark, in like manner, we find five layers, 8, 9, not so easily distinguishable, of which the inner 8, being softer, are named the *Liber*, or *Inner Bark;* the outer, 9, or harder, the *Cortex*, or *Outer Bark*. Externally to the latter is the *Herbaceous Envelope*, 10, which is cellular, and of a green colour; and, lastly, at the surface of the stem, the *Epidermis* or *Cuticle*, 11. Proceeding from the pith or its sheath, and traversing the woody layers, in the form of radii, as seen in a transverse section of the stem, are numerous vertical plates of a kind of cellular tissue, usually named *Medullary Rays*. This name, however, being apt to deceive the student, I shall call them, what they really are, *Medullary Plates*. Similar medullary plates, but much less conspicuous, are observed in the bark. Let us now examine these parts in succession, beginning with the outermost.

63. *The Epidermis.*—The *Epidermis* or *Cuticle*, already described, p. 14, as the general integument of plants, is very apparent in young stems or twigs, from which it

may be easily separated. Since it is constantly distended by the cortical layers, as the stem enlarges in diameter, and has only a certain degree of extensibility, it is torn and destroyed when the trunk has acquired a certain size. This original epidermis must not be confounded with that of old trunks, which is the outer layer of the herbaceous envelope, hardened by contact with the air. This latter kind of epidermis also tears and splits in proportion as the trunk increases in thickness, sometimes dividing longitudinally and sometimes transversely. Sometimes it separates in plates, and is quickly renewed, as is seen in the White Birch, in which numerous layers exist at the same time. The epidermis is often coloured with the juices of the subjacent cellular tissue, but when washed, it is transparent and of a grayish-white. It is composed of one or several plates of cellules covered by a delicate membrane, and when young, presents the minute apertures named Stomata, p. 15, which, however, are only found on stems directly exposed to air and light, for the epidermis of stems placed under ground or in water, and that of roots are entirely destitute of them. The surface of the epidermis is also furnished in some dicotyledonous plants with small glands, named *Lenticels;* and is generally or frequently covered with hairs, § 21.

64. *The Herbaceous Envelope.*—When the epidermis is peeled off, which it may easily be in many twigs, as in the Elder, we find exposed a cellular tissue of a green colour. The reason of its appearing green is because it contains numerous small grains of that colour. It is very succulent, especially in spring, but as it becomes old, it assumes a white colour, like the central or inner pith. It is this substance which, being very highly developed, forms the *cork* of commerce. This substance detaches itself naturally every eight or nine years, and it

is usually separated artificially one or two years before this period; for this purpose that season of the year is chosen, when the inner bark adheres most closely to the wood, for then the whole cellular envelope may be removed, without fear of detaching the liber. If the herbaceous envelope be removed, it is reproduced. When old, it splits and tears, like the epidermis, in consequence of being distended by the pressure from within. This part appears to be of great importance, as it is here that the decomposition of the carbonic acid absorbed by the plant takes place.

65. *The Bark or Cortical Layers.*—On removing the herbaceous tissue, we come to the *Bark*, which is generally formed of a number of layers corresponding to the age of the tree. Every year there is formed a layer of bark, which is produced on the inner surface of the previously formed layer, so that this part increases in thickness by additions from within, while the wood increases by layers added to its surface. The outermost layer of the bark is thus the oldest. Some of those which are most external, having become hard, are distinguished by the name of the *Outer Bark*, or the *Cortical Layers.* Each of them is composed of longitudinal fibres, which are curved, or alternately separate and unite, so as to produce a kind of network. This disposition is very remarkable in some plants, and especially in the Lace-tree, in which the cortical layers, on being separated and stretched out, resemble lace, or linen of loose texture. The layers are traversed by medullary rays, proceeding from the herbaceous tissue, and penetrating in the form of pyramids through their meshes.

66. *The Liber or Inner Bark.*—The innermost part of the bark, which is named the *Liber*, is composed of a vascular network, of which the elongated meshes are filled with cellular tissue. Its different laminæ are also

separated by thin layers of cellular tissue. Like the other parts of the bark, it is capable of being reproduced when it has been removed; but in this case it must be guarded against the contact of air. It is one of the most essential organs of vegetation, and is the seat of the *cambium*, or elaborated juice from which the different parts are produced. The liber is hardened each year, forming a layer of the bark, and by means of the cambium new layers are formed at its inner surface. The inner bark was named *liber*, from its being in some cases made into paper, or from its layers being frequently separable, like the leaves of a book. Paper was formerly made by the Egyptians from the *papyrus antiquorum*, a species of reed growing on the banks of the Nile. The inner bark of the stem was separated by means of a needle into thin plates or ribands, which were united together until they formed the size required, and were then pressed and dried in the sun. The plates in the centre were considered the best; and each plate diminished in value according as it receded from that part.

67. The division of the bark into cortical, *cellular*, or herbaceous envelope, and liber, or *fibrous* inner bark, has not been found sufficiently precise to explain the structural peculiarities in all cases. By the best modern writers, bark is described as composed of four distinct parts:—

(1). *Epidermis*, or the external and cellular envelope, continuous with the epidermis of the leaves. This is never renewed. The following parts increase by successive additions to their interior.

(2). *Epiphlœum*, or a cellular portion lying immediately under the epidermis. Cork is the epiphlœum of Quercus suber.

(3). *Mesophlœum*, or a cellular portion, lying imme-

diately under the epiphlœum. This portion differs from the preceding in the direction of its cells.

(4). *Endophlœum*, or liber, a part of which is cellular, and a part woody.

68. *The Woody Layers.*—Beneath the liber or innermost layer of the bark, we find the *Wood*, composed of the *Alburnum* externally, the *Duramen* or hard wood toward the interior, and the *Pith.* The Alburnum is not essentially different from the hard wood, being merely wood in a young state, not yet fully hardened, and generally of a paler colour. In trees of which the wood is very hard and compact, such as Ebony, Logwood, and Laburnum, there is a very marked distinction as to colour between the wood properly so called, and the Alburnum, the former being much darker; but in trees, of which the wood is soft and white, such as Willows and Pines, there is very little difference in this respect. At the end of some years, the layers of alburnum become converted into wood. This change, however, does not take place with regularity as to time or extent. One part of a layer of alburnum may be seen indurated, while another remains soft; and sometimes a tree is seen to have more layers soft on one side than on another. Once hardened, the woody layers no longer increase in thickness or length, and their vessels generally become impervious to fluids. The wood is composed of elongated cellular tissue, commonly called Woody Fibre, § 13, and is traversed by vessels of the kind named Ducts, § 16. The layer nearest the central pith is the oldest, and a new layer is formed each year, in contact with the liber or inner bark.

69. *Inverse Analogy between the Bark and the Wood.*—There is a beautiful analogy subsisting between the cortical and the woody systems. 1. The older layers of the bark are forced outwards, and constitute the *cortical*

layers, properly so called. They are the analogue of the heart-wood of the stem, with this difference,—that the one undergoes distension, while the other remains as deposited; the fibres of the one become more or less flexuous from pressure beneath; those of the other continue rectilinear. 2. *Woody layers* continue to be sap-wood, till they are converted into heart-wood, and become hard; *cortical layers* are distended, half-disorganized before this period, lose their freshness much sooner, and never attain the same degree of solidity. The former always retain their thickness; the latter become thin, from distension and separation of their fibres. The former, sheltered from atmospheric influences, retain their vitality; the latter, exposed to these influences, dry up, split, and assume darker complexions.

70. *The Pith and its Sheath.*—Within the innermost layer of wood is the *Medullary Sheath* or *Tube*, which is formed of ducts intermixed with spiral vessels. Although generally cylindrical, it presents, in its transverse section, various forms, being angular or elliptical. Once formed, it no longer changes its form or dimensions, but remains the same during the whole life of the plant. The *Pith* or *Medulla*, is a spongy substance, formed of cellular tissue, and sometimes longitudinally traversed by a few vessels. Its cellules are larger, and more regularly arranged than those of any other part. In herbaceous plants, in young shoots, and woody stems of the first year, it is green and juicy, like the external herbaceous envelope; but, in the progress of vegetation, it loses its fluids and green colour, and is generally found to be dry and white. In some plants which have a rapid growth, it becomes torn, and nearly disappears, leaving the stem hollow.

71. *Medullary Rays.*—The thin vertical plates of cellular tissue, which are seen passing from the pith or

medullary sheath, through the layers of the wood, are what carpenters call the "silver grain." The beauty of the wood, in fact, depends chiefly upon the manner in which it has been cut, whether perpendicularly to the medullary plates, or so as to divide them obliquely. Although the plates which proceed from the pith run out to the outermost layer of the wood, yet each successive layer of wood shows additional plates originating from or terminating in it; so that, where there may be twenty plates traversing the innermost layer, there may be twenty times that number traversing the outermost.

72. *Structure of the Monocotyledonous Stem.*—The woody stem of a monocotyledonous plant (Fig. 11, *b*), presents a very different appearance from that of a dicotyledonous tree. This kind of stem is not formed of two bodies, increasing in two opposite directions; and its transverse section shows no circular layers of wood, alburnum, liber, and bark; all these parts seeming, as it were, confounded together in it. The interior of such a stem is composed of cellular tissue, traversed by longitudinal fasciculi of vessels; and its bark is seldom distinguishable from the rest. In the dicotyledonous stem the hardest part is that nearest the centre; but in the monocotyledonous, that nearest the circumference has most solidity. Such is the structure of the stipe in Palms, and that of other families of this class is more or less analogous, although they present differences. Thus, in Bamboos, and grasses generally, the stem is hollow.

73. *Structure of the Root similar to that of the Stem.*—Reverting to the structure of the root, already described in § 33, it may be remarked, that it generally corresponds to that of the stem. Thus, in dicotyledonous trees, a transverse section shows layers of woody tissue, although not so distinctly defined, and a cortical body, together with medullary plates. The pith, however, is

wanting, and there are neither spiral vessels nor stomata. In monocotyledonous trees, the root, instead of tapering, is composed of numerous fibres or radicles, issuing from the neck. The root and the stem in all plants form two conical or cylindrical bodies, applied against each other by their bases, and growing by their summits. These bodies branch in opposite directions, the stem dividing upwards, the root downwards.

Recapitulation.

44. What is meant by the stem? Are any phanerogamous plants stemless? What other parts are liable to be mistaken for stems? Are any kinds of stem apt to be considered as roots? 45. What are the principal kinds of stem? 46. Give an account of the Cormus. 47. What is the Tuber? 48. Define the Creeping Stem. 49. Describe the Rhizoma. 50. What is meant by the stem properly so called? 51. Describe the Trunk. 52. In what respect is the Stipe different? 53. What is the nature of the Culm? 54. Are there any other varieties of the stem? 55. Distinguish between Herbs, Shrubs, and Trees. Explain any other terms which suggest differences in the consistence of stems. 56. Describe the different characters of trees as produced by the modes of branching. 57. Explain the terms distichous, dichotomous, brachiate, and determinately-branched. 58. What appendages are sometimes found on the stem, in the absence of leaves? What is meant by a winged stem? What is meant by glabrous, farinaceous, and glaucous, as applied to the surface of stems? What is pubescence, and how are its varieties designated? 59. Distinguish between Thorns and Prickles. 60. Does the internal structure differ much in stems? 61. Of what two bodies are the woody stems of Dicotyledonous plants composed? 62. Mention all the parts more particularly, commencing at the centre. 63. Give a general account of the Epidermis. 64. What is the

nature of the Herbaceous Envelope? 65. Describe the Bark. Into how many parts is it divided? 66. What is the nature of the Liber? Whence is its name derived? Describe the process by which the ancients prepared paper. 67. What recent distinctions have been adopted in describing the structure of bark? 68. Describe the Woody layers. In what respect does the Alburnum differ from the Duramen? Of what is the wood composed? Which of its layers is the oldest? 69. Explain the inverse analogy which subsists between the cortical and the woody systems. 70. Give an account of the Pith and its Sheath. 71. Describe the Medullary Plates. 72. In what respects is the Monocotyledonous Stem different from the Dicotyledonous? 73. Has the structure of the Root any relation to that of the stem?

CHAPTER VII.

BUDS.

74. *Nature of Buds.*—A *Bud, Gemma,* is a body composed of the rudiments of some of the various organs of a plant generally inclosed within scales, and placed in

(Fig. 12.)

the axilla of a leaf, or at the extremity of a twig. Buds may be divided into *subterranean* and *aerial.* According

to the organs of which their outer scales are formed, they may be distinguished into:

1. *Leafy* or *Foliaceous*. *Gemmæ foliaceæ*. Those of which the scales are leaves that have not been developed; as in Mezereon.

2. *Petiolar*. *G. petiolaceæ*. When the scales are formed by the persistent bases of the leaf-stalks; as in the Walnut.

3. *Stipular*. *G. stipulaceæ*. When enveloped by the stipules; as in the Tulip-tree.

The scales of buds are always abortive organs, which, having served the purpose of protecting them, shrivel and fall off.

75. *Composition of Buds.*—According to the different shoots to which they give rise, buds are distinguished into three kinds:

1. *Leaf-Buds*. *G. foliiferæ*. Those which give rise to branches bearing leaves only.

2. *Flower-Buds*. *G. floriferæ*. Those which produce only flowers.

3. *Mixed Buds*. *G. mixtæ*. Those which give rise to both leaves and flowers.

Leaf-buds are generally of an ovate or elongated form; flower-buds, roundish; and mixed buds of an intermediate shape. The scales by which buds are enveloped, are frequently covered with resinous or glutinous matter, or with hairs, as if to protect them from the weather. In warm climates, buds are generally destitute of these coverings, and for this reason, among others, the trees of these countries are unable to resist the cold of our winters, and must therefore be sheltered.

76. *Arrangement of Buds.*—With respect to position, buds are either regular and symmetrical, or irregular and adventitious. The latter arise accidentally and

without order, after the evolution of the stem and leaves, in the roots, in the midst of the wood, on the edges, and on the surface of the leaves. Regular buds (Fig. 12), are found only at the ends of the branches, or in the axils of the leaves. They begin to form in summer, enlarge a little in autumn, remain stationary during winter, and in spring are gradually developed. The uppermost buds of a branch are those which are usually first developed. Buds may be variously disposed, being opposite to each other in pairs, or alternate, or in whorls; and upon this circumstance is dependent the division of the stem into branches. But as many of the buds are never developed, branches are not so symmetrically disposed as leaves.

77. *Development of Branches.*—Although, owing to various circumstances, such as an unfavourable situation for receiving moisture, air, or light, a bud may not be developed so as to form a branch, it yet generally continues to live, and being carried outward as the branch enlarges, may, under favourable circumstances, shoot out into a twig. The original direction of the buds determines that of the branches, which may come off from the stem at various angles, § 56.

78. *Subterranean Buds.*—Although the modifications presented by buds, which are developed under the surface of the soil, are numerous, it is useless to designate them all by different names; and, therefore, it will suffice here to allude to two kinds, the *Turio,* and the *Bulb.* The *Turio* is the subterranean scaly bud of a herbaceous plant, annually developed, and producing a new stem. Thus, the shoot of the common edible Asparagus is a Turio, as are the young shoots of grasses and other plants having a rhizoma or creeping stem. The Turio differs from the bud, in springing always from a perennial root, or rhizoma; that is, its origin is subterranean;

the bud always grows on a plant exposed to the air and light.

79. The *Bulb* is a bud belonging especially to certain perennial herbaceous Monocotyledonous Plants. This organ has usually been mistaken for a root; but the true root connected with it, § 40, consists of a *Disk* or parenchymatous plate, and a number of *fibres* or radicles, generally simple. To the disk are attached numerous fleshy scales, enclosing the rudiments of a stem and leaves. The arrangement of the scales gives rise to two kinds of bulbs:—

1. The *Coated* or *Tunicated Bulb*. *Bulbus tunicatus*. Pl. II., Fig. 14. Here the outer scales, which are thin and membranous, form each a continuous covering; as in the Onion, Hyacinth, and Daffodil.

2. The *Scaly* or *Squamous Bulb*. *B. squamosus*. Pl. II., Fig. 15. Here the outer scales are distinct, fleshy, and imbricated, like the inner scales; as in the White and Orange Lilies.

Bulbs are generally ovate or globular, and always of annual duration. Sometimes the bulb is *simple*, as in the Tulip; sometimes *multiple*, as in the Garlic. The new bulbs, which are developed in the axils of the bulb-leaves, sometimes arise in the centre of the old bulb, as in the Onion; sometimes by its side, as in the Tulip; or above it, as in *Gladiolus;* or beneath, as in *Ixia*.

80. *Bulbils*.—There is a kind of bud, which, although not subterranean, but capable of being developed upon different parts of a plant, is in all essential respects similar to the Bulb, and bears the name of *Bulbil*. It separates spontaneously from the stem, and on being placed in favourable circumstances, gives rise to a new plant. Of this kind are the small buds seen in the species of Lily named on that account *bulbiferum*, and in some species of Garlic. These bodies are not to be confounded

with Seeds, which have a very different structure, as will afterwards be explained.

Recapitulation.

74. Define a Bud. How are buds distinguished according to the organs of which their outer scales are formed? 75. How are they named, with reference to the parts to which they give rise? What is their general form? 76. How are buds arranged upon the stem? 77. Has the direction of the bud any effect upon that of the branches? 78. Are there any subterranean buds? Describe the Turio. In what does the Turio differ from the bud? 79. Give an account of the Bulb. How many varieties of it are there? Where are the new bulbs formed? 80. In what respects does the Bulbil differ from the bulb?

CHAPTER VIII.

FORM, STRUCTURE, AND RELATIONS OF THE LEAVES.

81. *General Idea of the Leaf.*—Attached to the sides of the stem are certain appendages, named Leaves, *Folia,* which are organs of respiration and evaporation. They are almost always green, and are composed of vascular fibres, here named *veins* or *nerves,* spread out so as to form a kind of network, of which the interstices are filled with cellular tissue, here termed *parenchyma,* the whole being covered with the epidermis. Although generally flat, they are sometimes, in succulent plants, cylindrical or of various forms, presenting the appearance of solid masses. The vessels which, in Dicotyledonous plants, come off from the medullary sheath, being at first close together in bundles, the basal part of the

leaf is narrow, and forms what is called the *Petiole*, or Leaf-stalk; but they subsequently expand and subdivide, to form the body of the leaf, which is technically named the *Limb*, or blade. These nerves or veins are composed of the same parts as the stem, namely of spiral vessels, ducts, and elongated cellules. In trees, the two surfaces of the leaf differ in structure and functions, the upper surface being generally smoother, firmer, more glossy, and furnished with fewer stomata; while the lower is duller, of a paler tint, and often covered with hairs. In herbaceous plants, the stomata exist equally on both surfaces. Leaves that float on the water, have them only on their upper surface, and those which are entirely immersed, are destitute of them.

82. *Arrangement of Leaves upon the Stem.*—1. Leaves have been named, with reference to the parts of the stem on which they grow, radical, cauline, ramous, and floral; or, more strictly speaking, only *cauline* and *ramous*, the former being developed from the stem, the latter from the branches. The *radical* leaves of botanists are cauline leaves, developed so near the root as to appear to arise from this organ, as in Hyacinth; while *floral* leaves are those which grow at the base or in the vicinity of flowers. 2. Leaves have been named, with reference to their succession during vegetation, seminal, primordial, and ordinary. *Seminal* leaves are formed inside the seed of many plants, and constitute what will hereafter be explained under the term *cotyledon*. By *primordial* leaves are denoted those which immediately succeed to the former. Pl. II., Fig. 7, represents the early leaves of the Garden Radish: the lower and reflected pair are the seminal, the interior and erect pair are the primordial leaves. The *ordinary* leaves are the proper cauline and ramous leaves of a plant. 3. Leaves are also named, with reference to their relation among

themselves, opposite, alternate, whorled, spiral, &c. These arrangements are important, being intimately connected with the general symmetry of plants.

83. 1. *Opposite* leaves, Pl. II., Fig. 6, are those which are developed in pairs, the leaves of each pair being opposite to each other, as in Mint. When the pairs alternately cross one another, the leaves are said to be *decussate,* as in Pl. IV., Fig. 28. 2. *Alternate* leaves, Pl. III., Fig. 21, are those which are developed alternately, the third above the first, the fourth above the second, as in Elm. 3. *Whorled* leaves, Pl. X., Fig. 127, are those which are developed around the stem, in numbers exceeding two, and from the same plane, as in Mare's-tail. When the whorl consists of three leaves, these are said to be *ternate;* when of four, *quaternate;* of five, *quinate;* and so on. 4. *Spiral* leaves are those which consist of more than five leaves, forming regular spires round the stem, as in the Screw-pine. These four arrangements may be reduced to two, namely the *whorl,* which, in its most reduced state, presents *opposite* leaves; and the *spiral,* which, under similar circumstances, exhibits *alternate* leaves. 5. Leaves are called *fasciculate,* Pl. IV., Fig. 26, when many are developed together from the same point, as in the Larch. 6. They are *imbricated,* Pl. IV., Fig. 27, when they overlap one another, in the manner of tiles on the roof of a house, and as occurs in

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DESCRIPTION OF PLATE IV. Fig. 26. Tufted Leaves. Fig. 27. Imbricated Leaves. Fig. 28. Decussate Leaves. Fig. 29. Distichous Leaves of Yew. Fig. 30. Unilateral Leaves. Fig. 31. Peltate Leaf of Nasturtium. Fig. 32. Amplexicaul Leaf. Fig. 33. Perfoliate Leaf. Fig. 34. Sheathing Leaf of a Grass. Fig. 35. Equitant Leaves. Fig. 36. Decurrent and Spinous Leaf. Fig. 37. Flower-bearing Leaf of Ruscus.

Heath, and in the fleshy leaves of the bulb (Pl. II., Fig. 15). They may be *biserial,* in two rows; *triserial,* in three; *quadriserial,* in four. 7. Leaves are *distichous,* Pl. IV., Fig. 29, when they are developed in two ranks, or spreading in two directions, as in Yew. 8. They are *unilateral,* Pl. IV., Fig. 30, when they lean toward one side, as in Solomon's Seal.

84. *Direction of Leaves.*—With respect to direction, leaves are *vertical* or perpendicular, in Iris; *erect,* or forming a very acute angle with the stem, as in *Juncus articulatus; close-pressed,* when they lie closely upon the stem; *spreading,* or patent, when they form a moderately acute angle with the stem; *horizontal,* when they spread at right angles; *reclinate,* inclining downward; *recurved,* bent backward; *incurved,* bent inward; *pendent,* directed downward; *reversed,* when the petiole is twisted, so that the lower surface is turned upward; *depressed,* when the radical leaves are pressed close to the ground, as in *Plantago media; floating,* when lying on the surface of water, as in Water Lily; *submersed,* when covered by water, as in *Hottonia palustris; emersed,* when rising out of the water, as in *Alisma plantago,* &c.

85. *The Petiole.*—When the bundle of fibres proceeding from the stem divides and spreads out at once, so as to occupy a portion of the circumference of the stem, and, being flat and of considerable breadth, not to be distinguishable from the lamina or blade, the leaf is said to be *sitting* or *sessile, Folium sessile,* Pl. IV., Fig. 30. But when, on the contrary, the bundle of fibres is prolonged before it expands into a membrane, and thus forms a distinct stalk, the leaf is said to be *petiolate, F. petiolatum,* Pl. III., Figs. 19, 21. Various circumstances relative to the petiole give rise to several varieties of insertion or attachment of the leaves.

86. *Insertion of Leaves.*—A leaf, whether sessile or

petiolate, may be attached to the stem in two different ways. Sometimes the cellular tissue of the leaf is continuous with that of the stem, and sometimes separated from it. In the former case, the leaf, on dying, remains attached to the stem in a withered state. In the latter case, the leaf is affixed by a kind of contraction, at which the fibres are closely united, and the cellular tissue interrupted.' Such a contraction is named a *joint* or *articulation*, and the leaf is said to be *articulated*. Leaves so attached are *caducous*, that is, fall off early in winter; and at night they assume a different position from that which they had by day; such leaves occur only in dicotyledonous plants, while the others are chiefly peculiar to monocotyledonous. Sessile leaves present the following modifications.

1. *Semiamplexicaul.* *F. semiamplexicaule.* When the base of the petiole is expanded, so as to embrace a large portion of the circumference of the stem.

2. *Amplexicaul.* *F. amplexicaule.* Pl. IV., Fig. 32. When it embraces the stem in its whole circumference; as in the Garden Poppy, *Papaver somniferum.*

3. *Sheathing* or *Vaginant.* *F. vaginans.* Pl. IV., Fig. 34. When the petiole, besides embracing the stem, is prolonged, so as to form a sheath to it; as in most Grasses.

4. *Perfoliate.* *F. perfoliatum.* Pl. IV., Fig. 33. When an amplexicaul leaf has its two sides at the base united, so as to appear as if the stem ran through it; as in *Bupleurum rotundifolium.*

5. *Connate Leaves.* *Folia connata.* Pl. III., Fig. 17. When two opposite sessile leaves are united by their bases; as in *Chlora perfoliata* and *Lonicera caprifolium.*

6. *Peltate.* When the petiole is inserted into the middle of the leaf, and the nerves issuing from it spread out in all directions, the leaf is said to be *peltate*, or

shield-shaped, *F. peltatum*, Pl. IV., Fig. 31; as in *Hydrocotyle vulgaris*, and *Tropœolum majus*.

87. *Form of the Petiole.*—The Petiole presents other circumstances, which require to be attended to. Thus, it may be *short* or *long*. Viewed with respect to form, it may be *round, compressed, three-sided*, or of some of the forms described in § 58. It may be *club-shaped, P. claviformis*, enlarged at its upper part; *winged, P. alatus*, having the leaf prolonged upon it, so as to form a membranous border on each side, as in the Orange; *leaf-like, P. foliiformis*, when so broad and thin as to have the appearance of a leaf. To this last kind, which exists in many of the Acacias of New Holland, some have given the name of *Phyllodium*. Very frequently the petiole has a groove along its upper surface, when it is said to be channelled, *P. canaliculatus*.

88. *The Limb or Blade.*—According to the different dispositions of the nerves, and the manner in which the parenchyma fills up their intervals, the limb or blade of the leaf assumes a great variety of forms. It will easily be understood, that the form or contour of a leaf is determined by the length to which the nerves or their ramifications extend, and that the entireness or indentation of the margin depends upon the degree in which the parenchyma is developed between them. These circumstances determining the particular form, it is obvious that a distinction into leaves, composed as it were of a single blade, and leaves composed of several pieces, or into simple and compound leaves, is of little real importance. A more philosophical distinction is, that a simple leaf has all its parts *continuous*, whether entire or divided in the greatest degree; while a compound leaf is that which has an *articulation*, as that of Orange. But as the former distinction is very obvious, and useful in arranging leaves for description, it may be well to retain it.

89. *Simple and Compound Leaves.* A *Simple Leaf* is one of which the limb consists of a single piece, Pl. V., of which the margin may be entire, Pl. V., Figs. 38, 39, or variously indented, Figs. 58, 59, and either sessile, Pl. IV,, Fig. 30, or petiolate, Pl. II., Fig. 21. A *Compound Leaf*, Pl. VIII., is one composed of several distinct pieces or *leaflets*, each of which is articulated to the petiole, or connected with it by a narrow part, in which the cellular tissue is wanting. For the reason mentioned above, it will be convenient to speak of the Simple and the Compound Leaves separately. But previous to this, it is of importance to describe the modes of distribution of the nerves.

90. *Nervation of Leaves.*—By the terms "nervation" and "venation," which are synonymous, is meant the distribution of the vascular fasciculi in the leaf. It is observed that, in monocotyledonous plants, the nerves are generally *simple* and *curved;* and that, in dicotyledonous plants, they are *branched* and *angular.* The degree and manner of branching give rise to several remarkable varieties.

91. *Curvinerved Leaves.*—When the nerves or vascular fasciculi all proceed from the base of the leaf, curve outwards to either side, assume a degree of parallelism, and traverse the limb in its whole length, the leaf is said to be *curvinerved,* Pl. VII., Figs. 89, 90. The nerves sometimes converge toward the tip, as in the figures referred to, or diverge, as in Pl. V., Fig. 60.

92. *Angulinerved Leaves.*—In dicotyledonous plants, the nerves, in issuing from the base, separate and form strong veins, Pl. IV., Fig. 31; or run together, so as to form a midrib, from which veins are given off on either side, Pl. VII., Figs. 88, 91. In this kind of leaf the fasciculi subdivide and unite in various degrees, forming a network; hence it tears in an irregular manner, while the

curvinerved leaf separates, when force is used, in the direction of the nerves, or from the apex to the base. The following varieties of the angulinerved leaf are described.

1. *Penninerved.* Pl. VI., Fig. 80; Pl. VII., Fig. 88. When the *midrib* or *primary nerve*, extends from the base to the tip, and emits on either side, in its whole length, *secondary* nerves, which subdivide in like manner.

2. *Palminerved.* Pl. VI., Fig. 65. When, instead of forming a midrib, the fasciculi of vessels diverge from the tip of the petiole, forming a number of equally strong nerves, which afterwards subdivide in the penninerved manner.

3. *Pedatinerved.* Pl. VIII., Fig. 114. This is a modification of the last, in which there are three principal nerves, those at the sides sending off large branches in the direction of the tip of the leaf.

4. *Peltinerved.* Pl. IV., Fig. 31. When the fasciculi diverge from the top of the petiole, radiating all round.

93. *Figure of Simple Leaves.*—The terms applied to leaves, as designative of the modifications in their out-

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DESCRIPTION OF PLATE V. Fig. 38. Orbicular Leaf. Fig. 39. Roundish Leaf. Fig. 40. Ovate Leaf. Fig. 41. Obovate Leaf. Fig. 42. Elliptical Leaf. Fig. 43. Spathulate Leaf. Fig. 44. Wedge-shaped Leaf. Fig. 45. Lanceolate Leaf. Fig. 46. Linear Leaf. Fig. 47. Needle-shaped Leaf. Fig. 48. Triangular Leaf. Fig. 49. Quadrangular and Abrupt Leaf. Fig. 50. Deltoid Leaf. Fig. 51. Rhomboidal Leaf. Fig. 52. Kidney-shaped Leaf. Fig. 53. Heart-shaped Leaf. Fig. 54. Crescent-shaped Leaf. Fig. 55. Sagittate Leaf. Fig. 56. Hastate Leaf. Fig. 57. Panduriform Leaf. Fig. 58. Runcinate Leaf. Fig. 59. Lyrate Leaf. Fig. 60. Cleft Leaf. Fig. 61. Three-lobed Leaf. Fig. 62. Sinuate Leaf. Fig. 63. Partite Leaf. Fig. 64. Laciniate Leaf.

line, margin, apex, and surface, are very numerous. Many of these are common terms, and of familiar application, as orbicular, ovate, elliptical, oblong, &c. These are figured in Pl. V., and the terms are fully explained in the glossary at the end of the volume. Some of these relate to the entire outline of the leaf, some to the base, some to the sides, the point, the margin, and the consistence of leaves.

94. *Compound Leaves.*—The modifications hitherto defined are those of the Simple Leaf, or that of which the limb or blade consists of a single piece. The Compound Leaf, or that composed of several distinct pieces, articulated upon a common stalk, presents several varieties. The petiole of such a leaf may be *simple* or *branched.* When it is simple, the leaf is said to be *compound,* properly so speaking; but when it is branched, the leaf is *doubly compound,* or *decompound.* Agreeably to what has been stated with respect to the arrangement of the nerves or veins of the leaf, § § 81, 90, it is found that they determine the form assumed by compound leaves, which may be divided into those of which the leaflets diverge from the summit of the petiole, or are *palminerved;* and those in which the leaflets come off from the sides of the petiole, or are *pinninerved.* There are other modifications, which, however, may all be referred to these.

Description of Plate VI. Fig. 65. Palmate Leaf. Fig. 66. Pinnatifid Leaf. Fig. 67. Doubly Pinnatifid Leaf. Fig. 68. Pectinate Leaf. Fig. 69. Unequal Leaf. Fig. 70. Erose Leaf. Fig. 71. Retuse Leaf. Fig. 72. Emarginate Leaf. Fig. 73. Acuminate Leaf. Fig. 74. Acute Leaf. Fig. 75. Thorn-pointed Leaf. Fig. 76. Cirrose Leaf. Fig. 77. Spinous Leaf. Fig. 78. Ciliate or Fringed Leaf. Fig. 79. Toothed Leaf. Fig. 80. Serrate Leaf. Fig. 81. Crenate Leaf.

95. *Palminerved Compound Leaves.*—Of the compound leaves, of which the leaflets diverge from the top of the leaf-stalk, the following are the principal varieties:—

1. *Fingered* or *Digitate. F. digitatum.* When several leaflets, their number not being regarded, proceed from the top of the petiole, as in *Trifolium*, where there are three, and in *Æsculus Hippocastanum*, where there are seven. It may even happen that there is only a single leaflet, and yet the leaf is considered compound, because in other species of the same genus it is clearly so. According to the number of leaflets, this kind of leaf is named—

2. *Ternate. F. ternatum.* Pl. VIII., Fig. 106. A digitate leaf, having three leaflets; as in Clover and Wood Sorrel.

3. *Quaternate*, of four leaflets; as in *Marsilea quadrifolia. Quinate*, of five; as in *Potentilla reptans. Septenate*, of seven, as in *Æsculus Hippocastanum.*

4. *Pedate. F. pedatum.* Pl. VIII., Fig. 114. A ternate leaf, of which the two lateral leaflets give off others; as in *Helleborus.*

96. *Pinninerved Compound Leaves.*—Of the compound leaves, of which the leaflets come off laterally from the petiole, there are several varieties. There may be one,

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Description of Plate VIII. Fig. 101. Diversiform Leaves of Mimosa verticillata. Fig. 102. Hooded Leaf of Sarracenia. Fig. 103. Appendiculate Leaf of Dionæa. Fig. 104. Articulated Leaf. Fig. 105. Binate Leaf. Fig. 106. Ternate Leaf. Fig. 107. Interruptedly-pinnate Leaf. Fig. 108. Lyrately-pinnate Leaf. Fig. 109. Verticillately-pinnate Leaf. Fig. 110. Auriculate Leaf. Fig. 111. Compound Pinnate Leaf. Fig. 112. Doubly Compound, or Biternate Leaf. Fig. 113. Thrice Compound, or Triternate Leaf. Fig. 114. Pedate Leaf of Helleborus.

two, three, or more pairs of leaflets, and the leaves are then termed, respectively, *conjugate*, Pl. VIII., Fig. 105, *bijugate*, *trijugate*, &c. Or the leaflets may be developed opposite to each other, in pairs, as in Rose; they are then said to be *oppositely-pinnate*, Pl. IX., Fig. 116; or the leaflets may be alternate, and the leaf termed *alternately-pinnate;* or the leaflets may be in pairs, while the summit of the common stalk ends either abruptly, Pl. VIII., Fig. 101, or in a tendril, Pl. IX., Fig. 115; these are the *abruptly-pinnate* leaves. Other modifications occur in the *impari-pinnate* leaf, in which the petiole of a pinnate leaf is terminated by a leaflet, as in Rose, Pl. VIII., Figs. 108, 110; in the *interruptedly-pinnate* leaf, in which the leaflets are alternately large and small, as in *Potentilla anserina*, Pl. VIII., Fig. 107; in the *lyrately-pinnate* leaf, in which the terminal leaflet is much larger than the rest, as in *Geum rivale*, Pl. VIII., Fig. 108; and in the *verticillately-pinnate* leaf, in which the leaflets are finely divided, and seem to embrace the petiole, as in *Sium verticillatum*, Pl. VIII., Fig. 109. When the petiole divides into secondary petioles, and these into others, the leaf is said to be *decompound*, and this may be *doubly*, Pl. VIII., Fig. 112, or *thrice*, Fig. 113. Lastly, a leaf may be *biternate*, Fig. 112, or *triternate*, Fig. 113; *bipinnate* or *tripinnate*.

97. *Summary.*—The whole question connected with the *forms of leaves*, may be explained by reference to a simple principle. The fibro-vascular tissue ramifies from the petiole, each of its ramifications being invested with parenchyma. These invested ramifications may remain separate from each other, as in the submersed leaves of *Ranunculus aquatilis;* or they may unite together, more or less, by development of parenchyma, so as to present all the lobed varieties of form. Sinuses, or indentations occurring between the lateral veins, give rise to *lobes*, or

the portions formed by *development of the secondary veins.*

1. The adhesion may take place through about half their extent. The projecting portions are called *divisions;* the sinuses, *fissures;* and the leaf is *pinnati-fid,* as in Hawthorn.

2. The lobes may be still less united by parenchyma, merely at their base; they are then called *partitions,* and the leaf is said to be *pinnati-partite.*

3. The lobes may be altogether unadherent, and are then called *segments;* the leaf is then said to be *pinnati-sected.*

4. The lobes may be isolated at their base, and adhere at the summit of the leaf, which is then termed *lyrate,* as in *Barbarea vulgaris.*

Sinuses occurring between the *tertiary veins,* give rise to *lobes,* which are *bi-pinnatifid, bi-pinnati-partite* or, *bi-pinnati-sected.* Beyond this, accurate division is not calculated; but we have leaves which are termed *multi-fid, laciniated,* and *decompound.*

98. In palminerved and peltinerved leaves, similar remarks apply, excepting that the *principal veins* of these leaves correspond to the *secondary veins* of the foregoing. Thus we have leaves which are called—

Palmati-fid,	*Pelti-fid.*
Palmati-partite,	*Pelti-partite,* or *pedati-partite.*
Palmati-sected,	*Pelti-sected,* or *pedati-sected.*

In pedati-nerved leaves, the secondary nerves or veins determine the lobes, as in the pinninerved.

99. In compound leaves a similar explanation may be given. The primary veins may remain distinct from one another, while the remaining branches anastomose, forming as many blades as there are primary veins; this gives us the *pinnate* leaf. Or the primary and the

secondary veins may be distinct, presenting the *bi-pinnate* leaf, from consolidation of the remaining ramifications. This principle may be extended to the *tri-pinnate* and further divisions of the leaf.

100. *Surface of Leaves.*—With regard to the pubescence, or hairs, on the surface of leaves, it will suffice to refer to what has already been said on the subject, § 21, 58; but there are other circumstances which require to be pointed out. Many of the terms applied to the surface of the stem, § 58, such as *even, smooth, glossy, powdery, watery, spotted,* and *striated,* apply equally to that of the leaves. They are also said to be *veiny,* Pl. VII., Fig. 88, when the vessels are branched, and prominent, forming a network; *nervous* or *ribbed,* Pl. VII., Fig. 89, when they extend in undivided longitudinal lines; *veinless* or *ribless,* when destitute of prominent vessels. *Three-ribbed,* Pl. VII., Fig. 90, when they present three distinct ribs from the base to the apex; *three-ribbed at the base,* Pl. VII., Fig. 91; and *triply-ribbed,* Pl. VII., Fig. 92, when a pair of large ribs come off from the midrib above the base.

101. *Colour and duration of Leaves.*—As has been already mentioned, the colour of leaves is generally

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Description of Plate VII. Fig. 82. Doubly Crenate Leaf. Fig. 83. Jagged Leaf. Fig. 84. Wavy Leaf. Fig. 85. Plaited Leaf. Fig. 86. Undulated Leaf. Fig. 87. Curled or Crisp Leaf. Fig. 88. Angulinerved Leaf. Fig. 89. Curvinerved Leaf. Fig. 90. Three-nerved Leaf. Fig. 91. Pinninerved Leaf. Fig. 92. Triply-nerved Leaf. Fig. 93. Cylindrical and Pointed Leaf. Fig. 94. Semicylindrical Leaf. Fig. 95. Awl-shaped Leaf. Fig. 96. Doubly tubular Leaf of Lobelia. Fig. 97. Canaliculate Leaf. Fig. 98. Dolabriform or Hatchet-shaped Leaf. Fig. 99. Three-edged Leaf. Fig. 100. Four-edged Leaf.

green, but of various tints. In the same species the tint varies in the course of its growth and decay. Very frequently the two surfaces of a leaf are of different tints, and sometimes, as in *Cyclamen Europæum*, conspicuously so. Sometimes, as in *Arum maculatum*, the leaves are patched or spotted with a darker or lighter colour. Leaves may also be parti-coloured in irregular masses; but this is generally a result of cultivation.

According to the periods during which leaves remain on the stem, they are named:—

1. *Caducous. F. caduca.* When they fall soon after their development; as in some species of Cactus.

2. *Deciduous. F. decidua.* When they fall before the next spring; as in the Elm and Ash.

3. *Marcescent. F. marcescentia.* When they wither before falling; as in the Oak and Beech.

4. *Persistent. F. persistentia.* When they remain longer than a year; as in Pines.

102. *Appendages of Leaves.*—Under this head may be included Stipules, Spines, and Tendrils.

The *Stipule* is a small leaf-like appendage to the leaf. It is commonly situated at the base of the petiole, in pairs, as in Pl. IX., Figs. 116, 122, either adhering to it, or standing separate. It is usually of a more delicate texture than the leaf, but varies in this respect, as well as in form and colour. In describing it the terms used for the leaf are employed. Stipules are generally considered as analogous to the leaves, or accessory to them, and are sometimes transformed into leaflets. Very few monocotyledonous plants have stipules; and the membranous part at the top of the sheath in grasses, although by many considered as such, seems to be of a different nature.

103. *Tendrils.*—The *Tendril, Cirrus,* Pl. IX., Fig. 122, is a prolongation of the petiole into a filiform body,

which by clasping objects, serves to support plants which have weak stems. Some tendrils, however, as in the Cucumber, are altered stipules; and others, as in the Vine, are transformed branches or flower-stalks.

104. *Spines.*—The Thorn, which is also named *Spina*, has been already described as an altered branch; but the *spine* here alluded to is considered as an alteration of the leaf or petiole. The spines which project from the edges of leaves, as in the Holly and Thistle, are clearly seen to be the extremities of the vascular fasciculi; and in the Barberry, the gradual transformation of the leaves into spines may be distinctly traced.

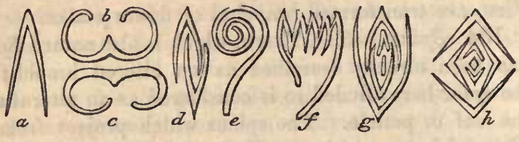
105. *The Pitcher.*—A very curious body, called the *pitcher*, appears to be a modification of the petiole and leaf, the body of the pitcher being the petiole, and the lid the leaf. When in its most perfect state, as in the Pitcher Plant, *Nepenthes destillatoria*, this is not so obvious, and it might be mistaken for a distinct organ, especially as it secretes a fluid. But in *Sarracenia*, Pl. VIII., Fig. 102, and more especially in *Dionæa muscipula*, Fig. 103, the transformation is obvious.

106. *Vernation.*—Having described the leaves sufficiently in detail to afford a pretty comprehensive knowledge of them, I may now say a few words respecting the manner in which they are folded up in the bud, previously to its expansion. This is named *Vernation*, while the folding of the parts of the flower is named *Æsti-*

Description of Plate IX. Fig. 115. Stipules, also Binate Leaf, with a tendril. Fig. 116. Stipules and Pinnate Leaf of Rosa. Fig. 117. Bractea of Tilia. Fig. 118. Bracteas of Lavandula. Fig. 119. Spinous Bracteas of Atractylis. Fig. 120. Thorns of Hippophaë. Fig. 121. Aculei, or Prickles of Rosa. Fig. 122. Cirrus, or Clasper. Fig. 123. Glandule-tipped Hairs of Rosa. Fig. 124. Hairs. Fig. 125. Bristles.

vation. The principal varieties of the former are the following:—

(Fig. 13.)



1. *Conduplicate. Vernatio conduplicativa.* (Fig. 13, *a*). The leaf folded lengthwise, one-half applied against the other, so that their margins correspond, as in *Philadelphus coronarius.*

2. *Revolute. V. revoluta. b.* Rolled backwards at the sides; as in Rosemary.

3. *Involute. V. involuta. c.* Rolled forwards; as in the Apple.

4. *Obvolute. V. obvoluta. d.* When two conduplicate leaves clasp each other.

5. *Circinate. V. circinata. e.* Rolled from the tip downwards.

6. *Plicate. V. plicata. f.* Folded lengthwise in several plaits; as in Alchemilla.

7. *Equitant. V. equitans. g.* Overlapping each other alternately and entirely; as in Iris.

8. *Imbricate. V. imbricata. h.* Overlapping each other, so that the middle of the outer leaf is opposite to the edges of two inner.

107. *General Remarks.*—Many of the terms applied to the leaves, are equally applicable to other organs of a similar nature, as the Bractea, Calyx, and Corolla. When a leaf is not precisely of any of the forms described above, such as *ovate,* but appears intermediate between that and another, such as *lanceolate,* it is defined by combining the two terms, *ovato-lanceolate.* The

leaves often gradually pass into the *Bracteæ* or floral leaves, presently to be described. In fact, the Leaves, the Bracteæ, and the different parts of the flower, namely, the Sepals, the Petals, the Stamens, and the Ovary, are merely modifications of one and the same organ.

Recapitulation.

81. What is the nature of Leaves? Are they always flat? What is the basal part of the leaf called? What name is given to the expanded part? Of what are the fibres of the leaf composed? What difference do leaves present with respect to their stomata? 82. What terms are applied to leaves with reference to the parts of the stem on which they grow? Are any of these terms inaccurate? What terms are used with reference to the succession of leaves during vegetation? Explain the terms seminal, primordial, and ordinary, as applied to leaves. 83. Distinguish between opposite and alternate leaves; between whorled and spiral leaves. How may these four arrangements be reduced to two? What is meant by the terms fasciculate, imbricated, decussate, distichous, and unilateral, as applied to the arrangement of leaves? 84. How are leaves named with reference to their direction? 85. When the petiole is not distinguishable from the limb, what is the leaf said to be? What is a petiolate leaf? 86. What is an articulated leaf? Are any leaves not articulated? What is meant by caducous? What are the principal modifications of sessile leaves? Distinguish between the perfoliate and connate leaves. What is a peltate leaf? 87. Does the petiole vary in length?—or in form? What is a winged petiole? Is the petiole often channelled? 88. What is the limb? Is its form affected by the nerves? 89. Define a simple leaf. What is a compound leaf? 90. What is meant by Nervation? 91. How many kinds of nervation are there? Define a curvinerved leaf. 92. What is an angulinerved leaf? How many varieties of it are there? 93. What are the principal terms

applied to leaves considered as to their figure or contour? 94. Define a compound leaf. What are the principal kinds of compound leaves? 95. Mention some varieties of palminerved compound leaves? 96. How many kinds of pinnate leaves are there? What are decompound and supradecompound leaves? 97. Upon what principle may the numerous forms of leaves be explained? 98. What is meant by lobes, divisions, fissures, and partitions of leaves? 99. Explain the principle of pinnation in leaves. 100. What terms apply to the surface of leaves? 101. Are leaves of any other colour than green? Is the duration of leaves various? 102. Give some account of the Stipule. 103. What is the Tendril? 104. How are Spines formed? 105. What is the Pitcher? 106. What is meant by Vernation? Mention some of its principal varieties.

CHAPTER IX.

INFLORESCENCE, OR THE MODE OF FLOWERING.

108. *General Remarks.*—The term *inflorescence* denotes the manner in which the flowers are arranged on plants. It relates, not to flowers, but to flower-stalks. Owing to the great diversity of aspect which inflorescence gives to plants, and the prominent characters which it affords, it requires especial attention. Under this head is included, not only inflorescence, properly so called, but an account of peduncles, pedicles, and bracts, with their modifications. Each flower of a bunch is supported on a little stalk, called a *pedicle;* the main stalk which supports all the flowers of a bunch and their pedicles, is called the *peduncle.* The pedicles, therefore, are the branches of a peduncle. What a petiole is to a leaf, a

pedicle or a peduncle is to a flower; and, as the presence or absence of a petiole constitutes a petiolate or a sessile leaf, so the presence or absence of a peduncle or a pedicle constitutes a *pedunculate* or *pedicellate*, or a *sessile* flower. In describing these organs, it will be convenient to call the peduncle the central or *primary axis* of inflorescence; the first divisions or branches of the peduncle, *secondary axes;* the next divisions, *tertiary axes.* A peduncle is distinguished from all other axes, by never bearing *true leaves;* the small, notched, leaf-like, membranous organs found on the axes of inflorescence, are not leaves, but *bracts*, or, as they are sometimes called, *floral leaves.*

109. *Position and Relations of the Peduncle.*—According to its situation, the flower-stalk is named *radical*, when it proceeds from the axil of a radical leaf, § 82, as in the Primrose and Cowslip. The radical peduncle is thus synonymous with the *Scape* of Linnæus, which is defined a stem or stalk that supports one or more flowers, but is destitute of leaves. But some botanists distinguish from the radical peduncle the scape, confining the latter term to the peduncle which arises directly from a radical bud, or from the midst of an assemblage of radical leaves; as in Hyacinth. The peduncle is also named *cauline*, when it springs directly from the stem; *rameal*, when it springs from the branches; *petiolar*, when united with the leaf-stalk; *epiphyllous*, when it springs from the surface of a leaf; as in *Ruscus aculeatus;* Pl. IV., Fig. 37; *axillar*, when it grows from the axil of a leaf, that is, between the stem or branch and the base of the leaf, or its stalk; as in *Anchusa sempervirens; extra-axillar*, when it arises beside the leaf; as in *Solanum dulcamara;* and *terminal*, when it is placed on the tip of a stem or branch, of which it appears to be the termination, as in *Centaurea scabiosa.*

Several other terms are applied to the peduncle, ac-

cording to its relations. Thus, it may be *solitary*, either single on a plant, as in *Rubus Chamæmorus*, or single in several parts of the same plant, as in *Antirrhinum spurium*. When several peduncles grow together, they are said to be *clustered*, or aggregate. When they are irregularly dispersed over the stem, they are termed *scattered*. A peduncle may bear one, two, three, or more flowers, and it is then called, respectively, *unifloral*, *bifloral*, *trifloral*, *multifloral*.

110. *The Bractea*.—As the stipule is a kind of leafy appendage to the leaf, so the *bractea* is a kind of leaf connected with the flower, or attached to its stalk. In a general point of view, there is no precise limit between the leaf and the bractea. When the leaves gradually become smaller toward the flowers, without undergoing much alteration of form or colour, they are sometimes named *Floral Leaves*. In general, bracteæ may be distinguished from leaves, by their being placed close to the flower, by their smaller size, different form and colour, and thinner texture. It is very seldom that a plant is destitute of bracteæ, which, however, is the case in those belonging to the natural family of the Cruciferæ, such as the Cabbage and Mustard. As these organs vary in form, colour, and consistence, they are individually described in the same manner as the leaves. Thus a bractea may be lanceolate, ovate, or oblong; green, red, or purple; membranous, leafy, petaloid, or woody. The bracteæ present several remarkable modifications, which require separate consideration.

111. *Modifications of the Bracteæ*.—Under this head are included parts, which by many authors have been considered as belonging to the Flower properly so called. The following are modifications:—

1. *The Involucre. Involucrum*. Pl. XI., Fig. 143. When the bracteæ, or floral leaves, are so disposed round

one or more flowers, as to form a kind of envelope, they are collectively named an Involucre. Such an envelope may consist of three, four, five, or more leaves, and is then named *triphyllum*, *tetraphyllum*, *pentaphyllum*, *polyphyllum*. In the plants named Compound, such as the Thistle and Dandelion, the involucre is formed of numerous leaves, usually imbricated, which surround the expanded top of the peduncle, here named the *Receptacle*, or *Anthophore*, Pl. XVI., Fig. 209. In the plants named *Umbellate*, as the Carrot and Hemlock, where the peduncles, of which several come off together, branch in the same manner, the leaflets at the base of the peduncles are named the *Involucre*, while those at the base of the pedicels are named the *Involucels*, Pl. X., Figs. 137, 138.

2. *The Cupule. Cupula.* When the bracteæ are disposed close together around the flower, and remain, enlarging until the fruit is mature, as in the Oak, they are collectively named the Cupule, which may be of several kinds. When the bracteæ are small and scale-like, they form the cup of the Oak. They may be leafy, as in the Hazel; or of firm texture, and entirely covering the fruit, as in the Beech and Chestnut.

3. *The Spatha.* When the bractea, or involucrum, is very large, membranous, and encloses the flowers previous to expansion, as in *Arum* and *Narcissus*, it is named a *Sheath* or *Spatha*, Pl. XII., Fig. 147.

Many other modifications might be adduced; but it will suffice to mention one of the most remarkable, that which occurs in the Grasses.

112. *Bracteæ in the Grasses.*—The plants to which we give the name of Grasses, such as Wheat, Oats, and Rye-Grass, present a peculiar arrangement of the bracteæ, which assume the place of the calyx and corolla. A great diversity of opinion has taken place regarding the

nature and nomenclature of these organs. They may, however, be described thus. Pl. XII., Fig. 148. Externally are two opposite, thin bracteæ, one placed a little above the other. Within these are two smaller, also opposite organs of a similar nature, one of them often furnished with an awn, or long rigid and twisted bristle-like body. Within these, at the base of the seed, or its germ, are two or three minute, generally fleshy scales. The outer scales, or valves, are by some considered the calyx, the inner as the corolla, and the innermost as nectaries. Others regard the outer as bracteæ, the inner as the calyx, and the innermost as the corolla. Others consider all these parts as bracteæ. Professor Lindley names the outer scales *glumæ;* the inner, *paleæ;* and the minute scales, *squamulæ.* In Carex, two bracts become confluent at their edges, and enclose the pistil; the single body formed by this cohesion, is called *urceolus.*

113. *The Inflorescence.*—Leaving the consideration of the Flowers for the next chapter, we have here to describe the manner in which they are arranged. The circumstances of flowers being *solitary*, *terminal*, *lateral*, or *axillar*, will be understood from what has been said of the peduncle, § 109. The principal varieties presented by the arrangement of the flowers upon the stem, or its continuation, are the following:—

1. *The Whorl. Verticillus.* Pl. X., Fig. 127. When the flowers surround the stem; as in *Hippuris vulgaris.* Many authors include under this head the flowers of the

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Description of Plate XI. Fig. 139. Cyme of Laurustinus. Fig. 140. Panicle of Avena. Fig. 141. Thyrsus. Fig. 142. Calyx of Dianthus. Fig. 143. Involucrum of Anemone. Fig. 144. Sori and Indusia of a Fern. Fig. 145. Indusium and Sorus; also, Capsule and Ring of a Fern. Fig. 146. Catkin of Hazel, with separate bracteæ and stamens.

Labiatæ, or such plants as the Dead Nettle, Pl. X., Fig. 126. But in this case, the flowers grow in two opposite clusters in the axils of the leaves, and thus do not surround the stem. These clusters have been named *verticillastri*, or false whorls. Whorled flowers never occur, except in cases in which the leaves are whorled.

114. SIMPLE MODES OF INFLORESCENCE.—The following are the kinds that present the most simple arrangement:—

2. *The Spike. Spica.* Pl. X., Figs. 129, 130, 131. When a common unbranched peduncle bears numerous flowers, which are either sessile, or have pedicels so short as to be inconspicuous. Wheat, Barley, Rye, and the Orchises afford examples of this kind of inflorescence, in which the lower flowers are always first developed, and the upper follow in succession. In the spike the flowers may be arranged spirally, or all round, or inclining to one side, or on two opposite sides. In grasses, the divisions of the inflorescence are terminated by *Spikelets*, *Spiculæ*, Pl. X., Fig. 131.

3. *The Raceme. Racemus.* Pl. X., Fig. 128. When a common unbranched peduncle bears numerous flowers, which are furnished with pedicels; as in *Ribes nigrum*, and *R. rubrum*.

DESCRIPTION OF PLATE X. Fig. 126. Spurious Whorl of Lamium. Fig. 127. Verticillate Flowers and Leaves of Hippuris. Fig. 128. Raceme of Currant. Fig. 129. Spike, unilateral, of Ophrys spiralis. Fig. 130. Spicate Raceme of Veronica spicata. Fig. 131. Spikelet of Bromus. Fig. 132. Corymb. Fig. 133. Corymbose Fasciculus of Achillæa. Fig. 134. Fasciculus of Dianthus Armeria. Fig. 135. Capitulum, or Condensed Raceme. Fig. 136. Sertule, or Simple Umbel. Fig. 137. Simple Umbel and Involucrum. Fig. 138. Compound Umbel, with general and partial Involucres.

4. *The Capitulum.* Pl. X., Fig. 135. This is merely a very short spike, of which the flowers are placed close together; as in Clover.

5. *The Corymb. Corymbus.* Pl. X., Fig. 132. When in a raceme, or spike, the stalks of the flowers become gradually longer, from the highest to the lowest, so that all the flowers stand on nearly the same level; as in the Wall-flower and Cabbage.

6. *The Catkin. Amentum.* Pl. XI., Fig. 146. When the flowers of a spike have bracteæ in place of the calyx and corolla, and either after flowering or ripening, the whole falls off in a single piece; as in Willows and Alders.

7. *The Spadix.* When the flowers are closely arranged round a fleshy peduncle, and inclosed in a spatha; as in Palms and Arums.

8. *The Anthodium.* When in place of a common stalk, there is a broad convex or flattened surface, on which numerous sessile flowers are arranged, the whole being inclosed within an involucre, as in the plants named Compositæ, such as the Daisy and Thistle. The flowers, or florets, of the outer circle, which generally differ in form from the rest, and are larger, are named *florets of the ray*, while the others are named *florets of the disk.*

9. *The Sertule. Sertula.* Pl. X., Fig. 136. When from the summit of the peduncle proceed several, generally elongated pedicels, nearly of equal length, each bearing a flower; as in *Allium ursinum*. By many authors this kind of inflorescence is termed a *simple umbel.* But the application of a distinct name to it is censured; although, on the same grounds, the use of raceme and corymb ought to be rejected, these modes of inflorescence being merely modifications of the spike.

115. MORE COMPLEX MODES OF INFLORESCENCE.—The above varieties may be considered as *simple*, while the following are *compound*,—

10. *The Umbel. Umbella.* Pl. X., Fig. 138. When from the summit of the stalk proceed several stalks or rays, of nearly equal length, each of which gives rise to a number of rays, bearing flowers. This is what is called a *Compound Umbel,* and is the general mode of inflorescence in the family of plants named *Umbelliferæ.* In a very few of these plants, however, the umbel is simple, and resembles the sertule above described. The primary rays are collectively named the *Umbel,* the secondary the *Umbellule*; the bracteæ at the base of the former constitute the *Involucre,* and those at the base of the latter, the *Involucel.*

11. *The Panicle. Panicula.* Pl. XI., Fig. 140. This may be considered as a compound Raceme. When the main stalk gives off, instead of single flowers, branches bearing several flowers, and subdividing in various degrees, we have a Panicle; as in the Oat, and many other Grasses.

12. *The Thyrsus.* Pl. XI., Fig. 141. When a panicle is very dense, and of an oblong or pyramidal form; as in the Lilac, Privet, and Horse-chestnut.

13. *The Cyme. Cyma.* Pl. XI., Fig. 139. When from a single point proceed several branches, each of which subdivides irregularly, bearing numerous flowers, placed nearly on a level; as in the Elder.

14. *The Fascicle. Fasciculus.* Pl. X., Fig. 134. When peduncles variously subdivided into short pedicels, bear numerous flowers collected into a close bundle, and nearly level at the top; as in Sweet-William.

In describing plants, adjectives derived from the above terms are often employed; for example, *Corymbose flowers, Umbellate, Fasciculate, Panicled, Racemose.*

116. *General Remarks.*—In all the above modifications of the Spike and Umbel, the flowers are developed from below upwards, or from without inwards, the upper-

most or central flower being the last to expand. But in the cyme, the central flowers are first developed, and to this mode of inflorescence may be referred the dichotomous stem, in which at each bifurcation is situated a pedicellate flower. In this case it may be said that the stem, in place of bearing flowers on its sides only, and being capable of indefinite prolongation, is terminated by a central flower, having at the base of its pedicel, bracteæ, usually two in number, which from their axils produce two new branches, each with a terminal flower; and so on indefinitely.

117. *Definite and Indefinite Inflorescence.*—The varieties of inflorescence may all be reduced to two classes, namely,

1. *Definite or Determinate Inflorescence.*
2. *Indefinite or Indeterminate Inflorescence.*

In definite inflorescence, the *evolution of the flowers* commences with the terminal flower of the primary axis, § 108; then the terminal flowers of the secondary axes open, in the direction from the summit or centre of the inflorescence to the base or circumference; then the lateral flowers which terminate the tertiary axes, proceeding also from the summit to the base. This is termed *centrifugal evolution*, Pl. XI., Fig. 139.

118. In indefinite inflorescence, the *evolution of the flowers* commences from the base or margin of the inflorescence, and proceeds to the summit or centre. This is termed *centripetal evolution*, Pl. X., Fig. 130.

119. The *Cyme* may be taken as the type of *definite inflorescence.* In chick-weed and in most caryophyllaceous plants, a series of bifurcations is found, in the centre of each of which is a solitary flower which terminates the inflorescence in each axis. This is the dichotomous and simplest form of the Cyme. In the genus Euphorbia this principle is extended, and there may be

a whorl of three, four, or five bracts, giving rise to a trichotomous, tetrachotomous, or pentachotomous cyme. In some plants, as Echium, Drosera, &c., one of the axes of each bifurcation is not developed; the flowers are then found all on one side, and the inflorescence becomes curled, presenting unilateral flowers. This is the *scorpioidal cyme.* The *Fascicle* belongs to the definite inflorescences, and may be described as a contracted cyme, in which the lateral branches are very short, as in Sweet-William.

120. The *Spike* and the *Raceme* may be taken as types of *indefinite inflorescence.* The spike is formed of sessile flowers situated in the axils of several bracts, as in Plantain. It admits of the following modifications:—1. The *Catkin* is a spike composed exclusively of male or of female flowers, which dries up and falls after flowering. There is less difference between the catkin and the spike than appears at first sight; in the same species of Willow the male flowers are often found arranged in a catkin or caducous spike, the females in a persistent spike. Some catkins have flowers with short pedicles, like racemes. In Pines we have branching catkins; that is, a central branch and several lateral branches. 2. The *Cone* is a spike in which the floral organs are extremely hard, persistent, and placed together closely like overlapping scales. The bracts constituting the cone are capable of enlarging after flowering, so as to appear an entire body. The female spike of the Hop is a kind of cone with membranous bracts. 3. The *Spadix* is a spike enveloped in one large sheathing bract, called a spatha. The spadix is simple in Arum; sometimes its whole extent is covered with flowers, sometimes its summit is naked. In Palms this spike branches, and is enveloped in an enormous bract; it is then called by the French, *régime.* 4. The *Spikelet* or locusta is a small lateral

spike, several of which are arranged around a central indefinite axis or *rachis*, in Grasses. The flowers of the spikelet are generally alternate, and compactly arranged along the axis. It is usual to term the inflorescence *spiked*, when the spikelets are arranged in a spike, as in wheat; *panicled*, when the spikelets are arranged in a panicle, as in millet.

121. The *Raceme* differs from the Spike only in the greater length of its pedicles. The flowers of the latter are said to be sessile ; those of the former pedicellate, as in hyacinth. To this must be added, that the pedicles are all of nearly equal length. The raceme admits of the following modifications:—1. The *Corymb* is a raceme in which the lower pedicles are so long that their flowers are elevated to the same level as that of the uppermost flowers. The inflorescence resembles an inverted cone. It might be mistaken for the fascicle, if the evolution of the latter were centripetal, instead of being centrifugal. 2. The *Umbel* is apparently remote from the raceme, but it is not really so. The pedicles are formed from one point, and the flowers present a plane, a convex, or a concave surface. If each of the pedicles bears a single flower—that is, if the secondary axes do not divide—we have the *simple umbel* of astrantia : if the pedicles divide, and bear other umbels, we have the *compound umbel* of heracleum. Among racemes there is an ornithogalum, with a very long axis ; there are others with a very short axis; there are plants in which the axis is so short that the pedicles appear all to spring from the summit, as in iberis; so that an umbel may be considered as a raceme, of which the axis is almost reduced to nothing. 3. In the *Capitulum*, the flowers of a simple umbel are deprived of their pedicles, and placed close together upon an enlarged axis, called the *receptacle*. If the receptacle is flat, and surrounded by an involucrum, the inflorescence of the com-

positæ is produced. In these plants, the flowers of the circumference are usually ligulate or strap-shaped, and are called *florets of the ray;* those in the centre are usually tubular, and are called *florets of the disk.*

122. The *Raceme* admits of several decompositions, more or less regular. 1. The *Panicle* is a raceme, which, instead of bearing single flowers, bears branches of flowers; or, in other words, the secondary axes ramify, as in the *simple* panicle of poa. When the rachis itself separates into irregular branches, so that it ceases to be an axis, as in some oncidiums, this is termed a *deliquescent* panicle. 2. The *Thyrsus* is a panicle, of which the lower branches are shorter than those of the middle, and the panicle itself is very compact.

123. *Combinations of Inflorescence.*—These are numerous. *Spikelets* of grasses are often *panicled.* Carex has flowers in compact *spikes* arranged along a central axis in *racemes.* Papyrus has flowers in *spikelets,* which are stalked and arranged like *umbels.* In Juncus, flowers occur in *capitula,* arranged in short *panicles.* The primary arrangement may be simple or compound; the secondary may resemble, or differ from that of the central axis. Again, the *inflorescence* of the *male* flowers frequently differs from that of the *female,* in the same plant. The males of the mais are arranged in a *branching spike;* the females in a *simple spike.* The males of the pine are in *catkins,* the females in *cones.* The males of the hop are *panicled;* the females are in a kind of cone or *spike.* The flowers of *hura crepitans* proceed from the same axil: the females are *solitary,* the males are *spiked.* Generally speaking, in these cases of disparity, the male flowers are more scattered and on the longer stalks.

124. *Intermediate kinds of Inflorescence.*—In some species of digitalis, and other plants, the lower flowers are

solitary, and situated at tolerable distances from one another, and are within the axils of large leaves ; while the upper flowers are very close to one another, and situated within the axils of minute bracts. This intermediate kind of inflorescence is termed the *spike* or *raceme, interrupted at its base,* or leafy at its base. Varieties occur, depending upon the more or less rapid transformation of the floral leaves into bracts, and the approximation of the flowers. Some inflorescences consist of a spike above and a raceme below ; or are spikes at an early period, and racemes at a later. Several spikes clustered together constitute a *ramose spike,* as in *Statice spicata.*

RECAPITULATION.

108. What is inflorescence ? Of what importance is it ? Explain the terms peduncle and pedicle. How is a peduncle distinguished from all other axes of growth ? What are bracts ? 109. What is a radical peduncle ? Define the scape. When a peduncle springs from the stem or branch, how is it named ? Mention some other terms expressive of the position and of the relations of the peduncle. 110. What is a bractea ? What is a floral leaf ? How are bracts described ? 111. What are the modifications of the bracts ? Give an account of the involucrum and of the involucellum. What is the cupule of the oak, of the hazel, of the beech ? Describe the spatha. 112. In what respects are the bracteæ of grasses remarkable ? Give a general description of them. 113. What is meant by a whorl ? Is the inflorescence of the Labiatæ a whorl ? How is it correctly described ? 114. Define a spike, and give examples of this kind of inflorescence. In what respect does the raceme differ from the spike ? What other forms of inflorescence seem to be modifications of the spike ? Describe the capitulum, the corymb, the catkin, the spadix, the anthodium, and the sertule. 115. Describe the umbel and the umbellule. What is a panicle ?

How does the thyrsus differ from the panicle? What is a cyme? What is a fascicle? 116. In what kinds of inflorescence are the lower or outer flowers first expanded? Describe the dichotomous mode of inflorescence. 117. To what two classes may all the varieties of inflorescence be reduced? Explain the mode of definite inflorescence. What is meant by centrifugal evolution? 118. Explain the mode of indefinite inflorescence. What is meant by centripetal evolution? 119. To which mode of inflorescence does the cyme belong? Explain the dichotomous cyme. What is a scorpioidal cyme? What other inflorescence is definite in its development? 120. To which mode of inflorescence belong the spike and the raceme? Explain the several modifications of the spike as they occur in the catkin, the cone, the spadix, and the spikelet. What is a rachis? 121. In what respect does the raceme differ from the spike? Explain the several modifications of the raceme, as exemplified in the corymb, the umbel, and the capitulum. 122. Of what decompositions does the raceme admit? Exemplify this in the panicle and the thyrsus. 123. Give some instances of combinations of inflorescence. Exemplify the difference which occurs in the inflorescence with reference to male and female flowers in the same plant. 124. Explain some intermediate modes of inflorescence.

CHAPTER X.

GENERAL CONSIDERATIONS RESPECTING THE ORGANS OF REPRODUCTION.

125. *General Idea of the Flower.*—The *Flower* may be defined that part of a plant which is especially subservient to the production of seeds. It is an apparatus composed of the organs of fructification properly so

called, and of those by which they are surrounded and protected. Considered with respect to structure, it is an assemblage of several whorls or series of leaves, more or less modified in their form and texture, and situated, in the form of a bud, at the extremity of the peduncle. In the state in which it presents itself in the more perfect dicotyledonous plants, it is composed of an outer whorl of leaves, the *Calyx;* an inner whorl of a more delicate texture, the *Corolla;* within this, the *Stamens;* and in the centre, the *Pistil* or *Ovary*, inclosing the *Seeds.* The point of attachment of the flower is named the *Receptacle* or *Torus.*

126. *Receptacle of the Flower.*—The summit of the peduncle generally expands in some degree, forming a kind of disk, from which the different parts of the flower arise. This expansion has sometimes the form of a fleshy protuberance, sometimes that of a mere plate, scarcely distinguishable, from which the corolla and stamens arise. This plate may be developed so as to be in some measure prolonged over the outer and inner parts of the flower, and sometimes it becomes thickened into a kind of disk. It may also happen that the peduncle is prolonged in the centre of the different parts of the flower, so as to form an axis around which they are symmetrically placed. Most commonly the flower terminates the peduncle.

127. *Forms of Receptacles.*—It is necessary to take a more extended view of this portion of the inflorescence, as it frequently presents an expansion of the summit of the axis, upon which a large number of flowers is placed. This expanded portion increases in size, in thickness, and in fleshiness, according to the number of flowers which it has to support, and to the nearer approach of the flowers to the sessile state. The receptacle has been termed the *phoranthium* and *clinanthium*—terms expressive of its

office of supporting flowers. In di- and tri-chotomous inflorescences, the expansion is scarcely perceptible ; in umbelliferous plants, a small quantity of nutritive matter is deposited in this part ; in composite plants, a very large quantity is stored up in the receptacle, and affords food for insects, and even for man, as in the artichoke. After the flowering season the receptacle dries up, and facilitates the expulsion of the fruits.

128. The *Forms* of the receptacle are numerous. It is cylindrical or conical in eryngo and teazle ; convex in many composite plants ; plane or slightly concave in dorstenia ; curved inward at its margins, in some species of this genus ; in the fig it is hollow, enclosing the flowers and the fruit; when perfectly ripe, this curious receptacle opens spontaneously at its upper extremity. Receptacles generally *change their form* at the period of maturity: the plane or convex bulge towards their centre; the concave open by reflexion of their borders,—for the purpose of discharging their fruits. In the common artichoke, cultivated for culinary purposes, the parts eaten are the fleshy bases of the bracts or scales of the involucrum, and the enlarged common receptacle, or the "seat," as it is popularly called. The eatable part of the bread-fruit (*Artocarpus incisa*) was described by Dampier, as being "as big as a penny loaf, when wheat is at 5s. the bushel, and all of a pure substance, like bread." The fruit of the jack or jaca tree (*A. integrifolia*) sometimes weighs upwards of thirty pounds, but is less esteemed as food. The juicy part of the raspberry consists of minute fruits arranged around an unpalatable spongy receptacle. In the strawberry, the receptacle itself forms the eatable part ; in the former, the fruits rob the receptacle of their nutriment ; in the latter, the receptacle robs the fruits, which are minute dry acini.

129. *Flower-Buds.*—Previously to entering upon the

consideration of the parts of the flower, it is necessary to advert to the bud of which it is the expansion. A careful and comparative examination of the various parts of which the flower is composed, and of the ordinary and accidental changes which they undergo, shows, as Professor Henslow remarks, that these organs are "modifications of a common germ, which may be developed according to circumstances, either in the form of a flower-bud, or of a leaf-bud, adapted in the one case to perform the functions of reproduction, and in the other those of nutrition. Flower-buds ought consequently to make their appearance on similar parts of the stem and branches with the leaf-buds, that is, in the axils of the leaves; and the development of such will present us with analogous phenomena. However different in their external characters, still the various parts of the inflorescence must bear a strong affinity to those of the leafy appendages on the branch."

130. *Æstivation.*—As the manner in which the leaves are disposed within the bud is technically named the *vernation*, p. 63, so that in which the parts of the flower are arranged previous to its expansion, is named the *Æstivation* or *Præfloration.* The principal modes in which the corolla, or its parts, the petals, are disposed in the bud, are the following:—

1. The petals, or divisions of the corolla, may cover each other laterally by a small portion of their breadth; as in *Rosa* and *Pyrus.* In this case they are said to be *imbricated. Æstivatio imbricativa.*

2. A corolla consisting of one piece may be folded upon itself, or *plaited. Æ. plicativa;* as in *Convolvulus.*

3. The petals, or the divisions of the corolla, may be spirally *twisted. Æ. torsiva;* as in *Oxalis.*

4. The petals may be *puckered,* or wrinkled. *Æ. corrugativa;* as in the Poppy.

5. They may be placed so as to have their edges in contact, like the valves or pieces of some seed-vessels. *Æ. valvaris.*

6. When there are five petals, two outer, two inner, and one covering the latter by one of its sides, the Æstivation is said to be *quincuncial. Æ. quincuncialis;* as in *Dianthus.*

The calyx also may present all the above circumstances, and the stamens may be erect, or bent inwards.

131. *Parts of the Flower.*—A flower, such as we may suppose complete, or possessed of all the parts that may enter into its composition, is externally formed of two whorls of leaves, constituting what is named the *floral envelope,* or *Perianth,* and internally of two other whorls of organs, which, if not resembling leaves in their form, are yet analogous to them, and constitute the essential parts of the flower, or the *Organs of Fructification.*

1. The outer whorl or envelope, is formed of several pieces named *Sepals,* which are either free, that is, disunited, or in some degree coherent by their margins. Collectively, they bear the name of *Calyx* or Flower-cup. They have much of the aspect and structure of leaves, and are generally green.

2. The next whorl, or second envelope, is formed of several pieces named *Petals,* which are also either free, or united, and are collectively named the *Corolla.* They are generally highly coloured, and of more delicate texture than the sepals, which, however, they often resemble, and into which they are sometimes transformed.

3. The third whorl is composed of the *Stamens,* which are free or united, and usually composed of two parts: an upper essential part, the *Anther,* a membranous bag, in which the *Pollen* or fecundating powder, is contained; and the *Filament* or stalk. The latter is sometimes foliaceous, and the anther itself is seen to be converted into

a petal in the case of what is called a *full flower*, produced by cultivation.

4. The fourth whorl, which is placed in the centre of the flower, is composed of pieces named *Carpels*, collectively called the *Pistil.* These pieces are sometimes free, generally united. A carpel is composed of three parts: a lower, usually of a roundish form, named the *Ovary*, which contains the *ovules* or young seeds; an upper, named the *Stigma*, which receives the pollen at the period of fecundation; and an intermediate part, named the *Style*, which, however, is sometimes wanting. The ovary is usually sessile, but is sometimes elevated on a stalk, analogous to the petiole of a leaf. Each carpel may be considered as a leaf folded inwards upon itself, and having its tip prolonged into a style.

It thus appears, that, whether the calyx, corolla, stamens and pistils, are to be considered simply as modified leaves, or as distinct parts, they yet have a very decided analogy to these organs; and the general idea of a uniformity of plan, merely presenting modifications according to circumstances, is useful in enabling the student more readily to apprehend and remember the series of organs.

Recapitulation.

125. What is the Flower considered as to function and structure? What parts enter into its composition? To what is it attached? 126. What is the Receptacle of the flower? Does it vary in form? 127. What terms have been applied to the receptacle? In which plants is the receptacle sparingly, in which largely developed? 128. Describe the various forms of the receptacle, particularly as it occurs in the fig. Explain the nature of the receptacle in the artichoke, the strawberry, and the raspberry. 129. Is there a direct analogy between Flower-buds and Leaf-buds? 130.

What is meant by Æstivation? Describe some of its varieties. 131. What is the Perianth? What are the Organs of Fructification? Give an account of the four whorls of which a flower is composed.

CHAPTER XI.

THE CALYX.

132. *General Idea of the Calyx.*—The *Perianth*, or floral envelope of the stamens and pistils, which are the only essential parts of the flower, may be entirely wanting. When present, it may be *single* or *double*. In the latter case it is composed of two whorls of leaves, which may be distinct, or in various degrees united by the edges. Should the two whorls themselves be united, the perianth may assume the appearance of a Calyx, or that of a Corolla, and thus it might be difficult to say whether it ought to be considered as a united calyx and corolla, or as either of these parts. Many writers say, that when the perianth is single, as in the Tulip and Lily, it ought to be considered as a calyx; others in such a case call it a calyx when thick, and more or less green, and a corolla when of delicate texture and highly coloured. In many cases, as in *Nymphæa*, the calyx and corolla pass so gradually into each other, that a distinction of the parts can hardly be made. Professor Lindley thinks the only just mode of distinguishing the calyx is to consider it in all cases the most exterior verticillate series of the flower, within the bracteæ, of whatever texture or colour it may be. A calyx therefore, he adds, can exist without a corolla; but a corolla cannot exist without a calyx. We may thus define the calyx the outermost

integument of the flower, consisting of two or more verticillate leaves, either distinct or united, usually green, and of a coarser texture than the corolla.

133. *Composition of the Calyx.*—The leaves of which the calyx is composed frequently cohere by their edges. As these leaves are named *Sepals,* such a calyx, consisting of a single piece, is named *monosepalous,* Pl. X., Fig. 126. For this term, however, M. Decandolle substitutes *gamosepalous,* implying that the calyx is composed of several united sepals, and not of one sepal only. It is *polysepalous,* when its leaves or sepals are distinct and separate, as in the Wall-flower, or in *Butomus umbellatus,* Pl. XII., Fig. 128. According to the number of the sepals, we may have a *di-*, *tri-*, *tetra-*, or *pentasepalous* calyx, denoting respectively the presence of two, three, four, or five sepals. Sometimes the calyx is united to, or covers, the ovary, in which case it is monosepalous and *superior.* The monosepalous calyx is generally *persistent,* that is, remains until the fruit is ripe. The polysepalous calyx is usually *caducous,* or falls off after the flower expands.

134. *Monosepalous Calyx.*—The cohering portion of the sepals constitutes the *tube* of the Calyx; the non-cohering, or upper portion, constitutes the *limb;* the part at which the tube and the limb unite, is called the *faux* or *throat.* The limb consists of divisions which, when large, are called *lobes;* when short and narrow, *teeth.* Sometimes the sepals cohere unequally, so as to leave a large space between certain lobes; a calyx is then said to have *lips:* two sepals may cohere, and form an *upper lip,* while three cohere to form a *lower lip;* the calyx is then termed *two-lipped,* Pl. XIII., Fig. 161, or all the sepals may cohere together to one side, constituting a *one-lipped* calyx.

135. The sepals having the characters of leaves, are

described by the terms applicable to these organs. Thus, with reference to their perfect or partial union, the monosepalous calyx is said to be *entire, toothed, cleft, partite,* &c. 1. With regard to form, the calyx is *tubular* in Primrose, Pl. XI., Fig. 142, *urceolate,* or pitcher-shaped in Rose, Pl. IX., Fig. 123, *inflated* in Bladder Campion; *campanulate,* or bell-shaped in Campanula; *cup-shaped,* or concave in Eucalyptus, Pl. X., Fig. 136, *calcarate,* spurred, or having a prolongation at the base, as in Trophy-cress, commonly called Nasturtium, Pl. XIII., Fig. 170.

136. In exogenous plants there are usually five sepals, or, in cases of cohesion, five lobes; occasionally, there are only three; more rarely, two, four, six, &c. In endogenous plants, there are commonly three sepals.

137. *The Pappus.*—A very curious modification of the Calyx is that to which the name of *Pappus* is given, Pl. XVI., Fig. 204. It is peculiar to plants belonging to the natural family of the *Compositæ,* and is familiarly exemplified in the Thistle, it being the part which crowns the pericarps of that plant, and by the aid of which they are conveyed to a distance by the winds. In these plants the ovary is placed below the corolla, and from its summit arises a crown of bristles or scales, which are analogous to the calyx, Pl. XVI., Fig. 210. This kind of calyx is persistent, remaining until the fruit is matured. It presents several modifications. Thus, it may be *sessile,* or proceeding directly from the summit of the ovary, without the intervention of any other body; or it may be supported upon a small stalk, when it is said to be *stipitate.* The filaments or hairs of which it is composed may be simple, in which case the pappus is said to be *pilose;* or they may have on their sides smaller filaments, resembling, in some measure, those of a feather, when the pappus is called *plumose* or *feathery.*

138. *General Remarks.*—In most cases the calyx is green, and resembles the leaves in texture. Frequently, however, it is of some other colour; and when the corolla is wanting, or the perianth single, it often assumes the most beautiful tints. In this case it is said to be *petaloid* or *corolliform*. Although generally shorter than the corolla, it sometimes equals or exceeds it in length. It may be *free*, or, on the other hand, in some degree *adherent* to the ovary. Its venation is that of the leaves, frequently penninerved. The central vein is termed primary or *carinal;* the vein which results from the cohesion of two adjacent sepals, is called *sutural.*

Recapitulation.

132. What is meant by the Perianth? Is it ever wanting? Is it always, when present, double? When single, how can it be determined whether it is a calyx or corolla? Define the Calyx. 133. What are the leaves of the calyx named? When the sepals are united, what term is applied to the calyx? What is a polysepalous calyx? What is meant by persistent and caducous? 134. What are the tube, the limb, and the throat of the calyx? What is meant by a two-lipped, by a one-lipped calyx? 135. Explain the terms urceolate, campanulate, and calcarate, as applied to the calyx. 136. What

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Description of Plate XIII. Corolla. Fig. 159. Campanulate or Bell-shaped Corolla. Fig. 160. Infundibuliform or Funnel-shaped Corolla. Fig. 161. Ringent, Gaping, or Bilabiate. Fig. 162. Personate or masked. Fig. 163. Papilionaceous. Fig. 164. Vexillum or Standard of the same. Fig. 165. Ala or Wing. Fig. 166. Carina or Keel. Fig. 167. Stamens and Style. Fig. 168. Incomplete Corolla of *Rittera.* Fig. 169. Peloria or regular-flowered variety of *Linaria vulgaris.* Fig. 170. Spur of the calyx of *Tropæolum.* Fig. 171. Horn-like petal of *Aquilegia.* Figs. 172, 173. Nectary of *Epimedium.*

is the usual number of sepals in exogenous and in endogenous plants? 137. Describe the Pappus. How many varieties does it present? 138. Is the calyx always green? What proportion does it bear to the corolla?

CHAPTER XII.

THE COROLLA.

139. *General Idea of the Corolla.*—Within the calyx is the *Corolla*, a whorl of leaves, of more delicate texture, and generally more highly coloured. It immediately surrounds the stamens, and is that part popularly called the Flower. The leaves of which this whorl is composed are named *Petals.* Like the sepals, or leaves of the calyx, the petals are either free, or united by the edges in various degrees. When they are united, the corolla is said to be *monopetalous* or *gamopetalous*, Pl. XIII., Fig. 159; when free, it is *polypetalous*, Pl. XIII., Fig. 163. In many cases each petal exhibits two more or less distinct parts; the *Claw*, *Unguis*, or lower, con-

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Description of Plate XII. Calyx and Corolla. Fig. 147. Spatha of *Narcissus; a.* the Sepals; *b.* the Crown. Fig. 148. Two glumes or husks of a grass, with two flowers within, each having an awn. Fig. 149. Awn or Arista of the same. Fig. 150. Scaly sheath and capsule of *Pterogonium Smithii.* Fig. 151. Calyptra or Veil of the same. Fig. 152. *Jungermannia epiphylla*, showing the Veil and unopened Capsule. Fig. 153. Volva or Radical Wrapper of an Agaricus. Fig. 154. Volva. Fig. 155. Hypocrateriform or Salver-shaped Corolla. Fig. 156. Cruciform Corolla. Fig. 157. A Petal of the same. Fig. 158. Unequal Corolla of *Butomus.*

tracted part by which it is attached to the receptacle; and the *Lamina*, or *Limb*, which is the expanded part, Pl. XII., Fig. 157. The unguis is thus analogous to the petiole, and the lamina to the blade of the leaf. The petals vary exceedingly in figure, being *roundish, ovate, lanceolate, obtuse, acute, entire, emarginate*, &c., the same terms being applied to them as to the leaves. When the petals, whether free or united, are equal to each other, the corolla is said to be *regular*, Pl. XII., Fig. 155, 156. When the reverse is the case, that is, when the petals are not equal, or when they adhere so as not to have a symmetrical form, it is *irregular*, Pl. XIII., Fig. 161, 163.

140. *Monopetalous Corolla.*—In a corolla of which the petals are united, three parts are distinguished:—1, a lower, narrow, more or less tubular and elongated part, named the *Tube. Tubus;* 2, a part continuous with the tube, more or less dilated, often spreading out flat, or even recurved, and named the *Limb, Limbus;* 3, the circular line at which the tube and limb unite, or the *Throat, Faux.* The tube is formed by the united claws, the limb by the laminæ of the petals. A monopetalous corolla may be regular or irregular.

141. *Regular Monopetalous Corolla.*—The semblance of various familiar objects is assumed by the monopetalous corolla in its modifications. Thus it may be,

1. *Bell-shaped* or *Campanulate. Corolla Campanulate.* When it resembles a bell, the tube being inconspicuous, the limb bulging out and gradually widening, with the mouth spreading; as in *Campanula*, Pl. XIII, Fig. 159.

2. *Funnel-shaped. C. infundibuliformis.* When the tube is narrow, but gradually dilates, and the limb preserves nearly the same direction; as in *Nicotiana.* Pl. XIII., Fig. 160.

3. *Tubular. C. tubulata.* When narrow and elongated. Pl. XVII., Fig. 212.

4. *Salver-shaped. C. hypocrateriformis.* When the tube is long, narrow, and nearly of equal diameter throughout, while the limb spreads out flat; as in the Primrose. Pl. XII., Fig. 155.

5. *Rotate* or *Wheel-shaped. C. rotata.* When the limb is spreading, and the tube very short; as in *Borago.*

6. *Pitcher-shaped. C. urceolata.* When globular or egg-shaped, and contracted at the mouth; as in *Vaccinium.*

142. *Irregular Monopetalous Corolla.*—The following are the principal varieties of this kind of corolla:—

1. *Ringent* or *Lipped. C. ringens, labiata.*—When the tube is narrow, the throat more or less dilated, and the limb divided into two unequal parts, one of which is named the upper, the other the lower *lip.* This kind of Corolla is seen in Rosemary, Thyme, the Deadnettle, and other plants of the natural family of *Labiatæ.* Pl. X., Fig. 126. Pl. XIII., Fig. 161.

2. *Masked* or *Personate. C. personata.* When the tube is more or less elongated, the throat wide, but closed by the approximation of the opposite sides of the limb, which is divided into two lips; as in *Antirrhinum.* Pl. XII., Fig. 162.

3. *Spurred. C. calcarata.* When the corolla has at its base a hollow prolongation like a horn; as in the figure last referred to.

4. *Strap-shaped. C. ligulata.* When tubular at the base, then slit on one side, so that the limb becomes flat; as in the Dandelion. Pl. XVI., Fig. 210, 211.

143. *Terms applied to the Parts.*—The various parts of the monopetalous corolla present numerous modifications, which require to be attended to. Thus:

1. The *Tube* may be *cylindrical,* as in the Lilac; *long,* as in the Primrose; *short,* as in the Bell-flower; *inflated* or bulging; *smooth, striated, angular,* &c.

2. The *Throat* may be *open*, as in Digitalis; *closed*, as in Snap-dragon; *crowned* with projecting teeth or appendages of various forms, as in Borage and Comfrey; *hairy*, as in Thyme; *naked*, or without hairs.

3. *The Limb* may be *erect*, as in Hound's-tongue; *spreading*, as in the Primrose; *reflexed*, or bent outward, as in Solanum; *toothed* on the margin, or according to the number and depth of its divisions, *trifid*, *quadrifid*, *quinquefid*, *tripartite*, *quadripartite*, *quinquepartite*. The divisions of the limb are described in the same manner as leaves.

144. *Polypetalous Corolla.*—When a corolla is composed of two petals, it is termed *dipetalous*; when of three, *tripetalous*; of four, *tetrapetalous*, Pl. XII., Fig. 156; of five, *pentapetalous*, Pl. XIV., Fig. 175; of six, *hexapetalous*. The petals may be *sessile*, or *unguiculate*; and the length of the unguis may be *shorter* or *longer* than the calyx. They may be—

1. *Erect. Petala erecta.* In the direction of the axis of the flower; as in *Geum rivale*.

2. *Spreading. P. patentia.* When they are nearly at right angles to the axis of the flower; as in *Rosa*.

3. *Reflected. P. reflexa.* When bent or curved outwards and downwards.

4. *Inflected. P. inflexa.* Curved toward the centre of the flower.

The petals vary exceedingly as to form in different plants, and are described in the same manner as the sepals and leaves, being *roundish*, *ovate*, *obovate*, *obcordate*, *elliptical*, *lanceolate*, *incised*, *lobed*, *smooth*, &c. Sometimes they present very singular forms. Thus, they are—

Helmet-shaped or *Galeated. P. galeiformia.* When vaulted, hollow, and somewhat resembling a helmet; as in Monk's-hood, *Aconitum Napellus*.

Cowl-shaped or *cuculliform*. *P. cuculliformia.* Having the form of a cowl or hood; as in Columbine and Larkspur.

Considered individually, a petal, as already stated, generally presents two distinct parts, the *Unguis* or *Claw*, and the *Lamina* or *Scale*, Pl. XII, Fig. 157. The claw is the narrow part at the base, by which the petal is attached to the receptacle, the lamina being the expanded part. The claw may be so short as to be scarcely distinguishable, or elongated so as to exceed the calyx.

As the monopetalous corolla may be regular or irregular, so also the polypetalous.

145. *Regular Polypetalous Corolla.*—Three principal modifications of this kind of Corolla are described.

1. The *Cruciform*. *C. cruciformis.* When four petals, having elongated claws, are placed in pairs, opposite to each other, in the manner of a cross; as in Wall-flower, Cabbage, and Water-cress, Pl. XII., Fig. 156.

2. *Caryophyllaceous*. *C. caryophyllacea.* When there are five petals, of which the claws are very long, and covered by the calyx, which is also very long and erect; as in the Pink and Catchfly, Pl. XI., Fig. 142.

3. *Rosaceous*. *C. rosacea.* When there are five roundish, spreading petals, of which the claws are very short; as in the Rose, Apple, Cherry, and Ranunculus, Pl. XIV., Fig. 175. The number of petals may vary, however, from three to six.

146. *Irregular Polypetalous Corolla.*—When the petals are unequal, the corolla is said to be irregular. This often happens in the Cruciform corolla above described, two of the petals being larger than the rest. Among the most remarkable corollas of this kind are the following:—

1. The *Papilionaceous*. *C. papilionacea.* Pl. XIII., Fig. 163. It is so named on account of its fancied

resemblance to a butterfly, and is composed of five petals, distinguished by appropriate names. The large petal at the back, Fig. 164, is named the *standard, vexillum;* the two lateral petals, which are equal, Fig. 165, the *wings, alæ;* and the two inferior petals, Fig. 166, also equal, and often united, by their lower margin, into a concave blade, named, from its appearance, the *keel, carina.* This kind of corolla is that seen in the great natural family of Leguminosæ, such as the Pea, the Bean, and Vetch. Sometimes, however, the petals of the papilionaceous corolla are united at the base, where they form a tube; as in Clover.

2. *Anomalous. C. anomala.* Consisting of five irregular petals, and somewhat resembling the papilionaceous corolla; as in the Violet.

3. *Incomplete. C. incompleta.* When petals, which analogy would lead us to expect, are wanting; as in *Rittera,* Pl. XIII., Fig. 168, a rosaceous corolla, having only a single petal.

147. *Position of the Petals.*—Considered with reference to the sepals, the sepals may be placed as follows:—

1. They may be *opposite* to the sepals, that is, the outer surface of the petal may be placed opposite to the inner surface of the sepal, so that the petals and sepals may correspond in position; as in the Barberry.

2. They may be *alternate,* that is, the petal may be placed, not opposite to the sepal, but opposite to the space between two sepals; as in the Wall-flower.

These circumstances refer not only to the polypetalous, but also to the monopetalous calyx and corolla.

The petals, whether united or free, may be placed upon the receptacle, immediately within or above the sepals, as in the Primrose and Ranunculus; or they may be attached to the margin of the tube of the calyx, at a distance from the receptacle, as in the Rose and Straw-

berry; or they may come off from the summit of the ovarium, as in the Thistle and Valerian.

148. *Other circumstances of the Corolla.*—The corolla, although generally longer than the calyx, may be shorter, and the relative proportions of the sepals and petals afford good distinctive characters. When the corolla falls off as soon as it expands, it is said to be *fugacious, C. fugax;* when it falls after the bursting of the anthers, it is *deciduous, C. decidua;* when it remains after fecundation, in a withered state, it is *marcescent, C. marcescens.* The colours exhibited by the corolla are of almost every possible variety of tint, excepting black, and depend upon the coloured fluids, or granules, in the cells of its tissue. The odours emitted by it are also extremely varied, although less capable of being defined. The petals are composed of cellular tissue, in which are distributed vascular fasciculi, and are covered on both surfaces with a delicate epidermis.

Recapitulation.

139. What is placed immediately within the calyx? What name is given to the leaves of the corolla? When the petals are united, what is it said to be? What is a polypetalous corolla? 140. What parts are distinguished in the monopetalous corolla? 141. What are the principal varieties, as to shape, of the regular monopetalous corolla? 142. Define a labiate corolla. Mention the varieties of the irregular monopetalous corolla. 143. Does the tube vary in form, and other circumstances? What modifications does the limb present? 144. How is a corolla named with reference to the number of its petals? What are the principal directions of the petals? How are they described? What singular forms do they present? Into how many parts is a petal divided? 145. What are the principal kinds of the regular polypetalous corolla? 146. Describe the papilionaceous corolla. What

is meant by anomalous and incomplete? 147. How are the petals placed with reference to the sepals? 148. What proportion does the corolla bear to the calyx? What terms referring to duration are applied to the corolla? Make a general statement as to its colours and odours. Of what are the petals composed?

CHAPTER XIII.

THE STAMENS.

149. *Nature of the Stamens.*—Within the corolla is a whorl of modified leaves, which differ so much in form from those organs, that their analogy could not at first sight be suspected. Their function too is different, for they are the organs by means of which the rudimentary ovula or seeds are impregnated. They are thus analogous to the male organs of animals, while the central part, or pistil, represents the female organ. The stamens and pistils then are the sexual or reproductive organs of plants. Generally they both exist in the same flower, which is thus said to be hermaphrodite or *perfect.* Sometimes, however, a flower has only stamens, when it is said to be *male* or *sterile;* or it has only pistils, when it is *female* or *fertile.* When a male flower and a female flower, or several flowers of each kind, are placed on the same individual plant, the latter is said to be *monœcious;* as the Hazel. When an individual plant bears flowers with stamens only, and another individual of the same species bears pistils only, the species is said to be *diœcious;* as the plant named Dog's Mercury. When on the same individual plant, or on different individuals of the same species, are placed male flowers, female flowers, and perfect flowers, the species is said to be *polygamous;*

as the Pellitory. In Pl. XIV., Fig. 175, are seen the tips of the five sepals, the five petals, the five stamens, the pistil in the centre, and between the stamen scales fringed with glandule-tipped filaments.

150. *Number and Proportion of Stamens.*—The number of stamens varies in different plants from one to a hundred or more. When a flower has only a single stamen, it is said to be *monandrous;* when it has two stamens, *diandrous;* when three, *triandrous;* when four, *tetrandrous;* five, *pentandrous;* six, *hexandrous;* seven, *heptandrous;* eight, *octandrous;* nine, *enneandrous;* ten, *decandrous*, &c. When a flower contains more than ten, but fewer than twenty, it is *dodecandrous;* and when a great number, *polyandrous.* Very frequently the stamens are *equal* in length, as in *Parnassia*, Pl. XIV., Fig. 175; but they are often *unequal.* When of four stamens, two are equal, and longer than the other two, the stamens are *didynamous;* as in the Dead Nettle and Thyme. Six stamens, of which four are equal and longer than the rest, are *tetradynamous;* as in the Wall-flower and Turnip. In many other cases, some of the stamens are longer than the rest, as in *Geranium* and *Malva*, but no particular terms are applied to them.

151. *Position and Direction of Stamens.*—Generally the stamens, when equal in number to the petals, are *alternate* with them; but sometimes they are *opposite* to the petals. When the number of stamens is double that of the petals, half of them are alternate, the other half opposite to the divisions of the corolla. They may be opposite to the sepals, as in most cases; or alternate. With respect to their direction, stamens are said to be *erect*, when parallel to the axis of the flower, as in Lilies; *inflected*, when curved toward the centre of the flower, as in *Lamium; reflected*, when bent outwards, as in *Parietaria; spreading*, when spread out at right angles

to the axis of the flower, as in *Rosa; pendulous,* when so slender as to be unable to support themselves, as in the Grasses; *ascending,* when directed toward the upper part of the flower, as in *Salvia; declinate,* when directed toward the lower part of the flower, as in *Æsculus.*

152. *Parts of the Stamen.*—The stamen is essentially composed of two parts; the *Anther, Anthera,* a membranous, generally two-celled sac; and the *Pollen,* a substance usually formed of numerous minute grains, containing the fecundating matter. Very frequently, however, a third part exists, namely the *Filament, Filamentum,* varying in length, and elevating the anther. The filament is thus merely an accessory part of the stamen, which is often *sessile,* being attached without the intervention of that part. Pl. XIV., Fig. 176, represents a stamen, *a,* being the filament, and *b,* the double-celled anther.

153. *The Filament.*—The filament presents various forms: it is usually *filiform,* or thread-like; but it may be *capillary,* or hair-like, as in Grasses; *subulate,* or awl-shaped, as in Tulip; *clavate,* or club-shaped; *cuneiform,* or wedge-shaped; *flattened* or *petaloid,* expanded and coloured like a petal. Filaments are usually separate, but they may contract adhesion: when all the filaments adhere together through a portion of their extent, so as to form a tube, they are said to be *monadelphous,* as in Mallow; when adhering in two sets, they are *diadelphous,* as in Fumitory; when in three or more parcels, they are *polyadelphous,* as in St. John's Wort.

154. *The Anther.*—The membranous sacs, constituting the *Anther, Anthera,* are generally two, and placed in contact with each other, but they are often more or less separated by the intervention of a body named the *Connective.* Although thus most commonly *bilocular,* the anther is sometimes *unilocular,* being composed of a

single cell; and more rarely *quadrilocular*. Each sac or cell has generally on some part of its surface a longitudinal groove, at which it opens. The surface on which this groove is placed, is named its *face*, while the other side is the *back*. Generally each cell has a longitudinal septum opposite the slit. Frequently the cells of the anther have little appendages, in the form of bristles or crests. The connective varies in form and extent, being usually little apparent, but sometimes very large. In the Sage it is forked, one division bearing a single-celled anther, the other bearing a rudimentary or abortive cell. In this case it is said to be *distractile*.

155. *Attachment and Direction of the Anther*.—1. The Anther may be *attached* by the middle of its length to the extremity of the filament; it then presents, before flowering, a vertical position, and afterwards a horizontal one; this is the *oscillating* or *versatile* anther. Or it may be inserted by one of its extremities to the top of the filament, of which it then appears to be a continuation; this is the *erect* anther. Or, it may be attached to the filament by a considerable portion of its length, so as to have no proper motion; this is the *adnate* anther. In this case the filament is frequently prolonged above the anther, in the form of an appendix, of a filiform, lamellated, or glandular appearance. Some writers employ the terms *basifixed* and *mediifixed*, the former denoting the attachment of the anther by its base to the top of the filament, the latter, the attachment of the summit of the filament to the middle of the back of the anther. 2. With respect to their *direction*, anthers are said to be *introrse*, when they face the axis of the flower; *extrorse*, when their face is directed outward.

156. *Form of the Anther*.—Anthers present a great variety of forms. Thus, they may be *spheroidal*, *globosæ*, as in *Mercurialis ; didymous*, *didymæ*, when of two

spheroidal lobes, as in *Euphorbia ovoidal, ovoidæ*; *oblong, oblongæ linear, lineares,* very long and narrow; *arrow-shaped, sagittatæ; heart-shaped, cordiformes; kidney-shaped, reniformes.* They may be *acute, acuminate, bifid, bipartite; two-horned, bicornes,* as in *Vaccinium Myrtillus; appendiculate, appendiculatæ,* having at their summit appendages of various kinds.

157. *Dehiscence of the Anther.*—Sometimes before the flower is expanded, and sometimes afterwards, the cells of the anther open, and allow the pollen or granules contained in them to escape. This opening, or dehiscence, most commonly takes place in the suture, or line of separation of the two valves, in which case the cells are said to be *longitudinally dehiscent, Loculi longitudinaliter dehiscentes;* as in the Tulip. Sometimes it takes place by slits or pores, which may be placed at the summit, *L. apice dehiscentes,* as in *Heaths;* or at the base, *L. basi dehiscentes,* as in *Pyrola.* Sometimes also it takes place by small valves; as in the Barberry.

158. *Cohesion of Anthers.*—Generally, even when the filaments are united or coherent, the anthers are free; but sometimes the anthers unite so as to form a kind of tube, surrounding the style. This is the case in the extensive family of plants, named, on this account, *Synantheræ,* such as the Dandelion, Daisy, and Thistle.

159. *The Pollen.*—The substance contained in the cells of the anther, and which is subservient to the fecundation of the ovules or rudimentary seeds, generally consists of a multitude of grains, and is named the *Pollen.* These grains vary much in form in various plants, being in most cases spherical or elliptical, sometimes cylindrical, square, triangular, flattened, or polyhedral. The membrane which surrounds the granules is generally smooth, sometimes bristly, or marked with prominences. When smooth, it is dry, but when covered with asperi-

ties, which are secreting organs, it has a clammy fluid spread over it. Although commonly distinct from each other, the grains sometimes cohere in clusters, or coalesce in masses. They are coated with two membranes, of which the inner is the more delicate. When immersed in water, they assume a spherical form, the outer coat bursts, and the inner projects at one or more points. The cavity of the grains is filled with granules of extreme minuteness, collectively named the *fovilla,* varying in form, and having a rotatory motion of great rapidity.

160. *Development and Dispersion of Pollen.*—At first the pollen presents itself in the form of a cellular mass filling the cavity of the cell of the anther, but having no attachment to its walls. By degrees the grains separate, enlarge, and assume their permanent form. When the cells of the anther open, the grains of pollen are generally discharged at once; but sometimes, when the discharge takes place by pores or holes, the grains are gradually emitted, and in greater quantity than would fill the cells, so that they must be successively secreted, or at least enlarged. Some of the grains of pollen falling on the stigma, which is generally covered with a clammy fluid, emit a process, which, gradually elongating, makes its way into the cellular tissue of the style. The ovules then enlarge, and are gradually perfected.

161. *Insertion of the Stamens.*—Three varieties of position with reference to the ovary are distinguishable, and considered of great importance in the arrangement of plants.

1. *Hypogynous Insertion.* When the stamens, whether their filaments be free, or adherent to a monopetalous corolla, are attached or inserted *beneath* the ovary, they are said to be *hypogynous;* as in the Poppy and Hyacinth.

2. *Perigynous Insertion.* When the stamens are in-

serted upon the inner surface of the calyx, at some distance from the axis of the flower, they are *perigynous;* as in the Rose and Strawberry.

3. *Epigynous Insertion.* When the stamens, whether their filaments be free, or attached to a monopetalous corolla, are inserted upon the summit of the ovary, they are *epigynous;* as in Hemlock and Campanula.

In reality, however, the stamens always originate from the space between the base of the petals and the base of the ovary; the apparent differences of insertion being produced by differences in the adhesion of the ovary and floral envelopes.

Sometimes the filaments are attached to the style, the male and female organs being thus in a manner united. In this case the flower is said to be *gynandrous,* as in Passion-flower.

162. *General Remarks.*—The filament consists of a bundle of woody fibre and spiral vessels, enveloped in cellular tissue, and is analogous to the petiole of the leaf. Although generally white, it is sometimes red, blue, or yellow. The anther, which is very frequently yellow, but also of other colours, is considered to be analogous to the lamina or expanded part of the leaf. Indeed, the gradual change of the petals, which are evidently modified leaves, into the stamens, is obvious in *Nymphæa,* and many other plants. In the stamen, however, there is a part, the fovilla, or mass of pollen, which has nothing analogous to it in the petals, sepals, or leaves. Judging from what takes place in *Nymphæa,* it would be better to consider the filament as representing the leaf, and the two cells of the anther to have no analogue.

RECAPITULATION.

149. What whorl is placed within that of the petals? What is the function of the stamens? To what are the sta-

mens and pistils analogous? Do they often exist together on the same flower? What is meant by perfect, sterile, and fertile flowers? What are monœcious, diœcious, and polygamous flowers? 150. What terms are applied to the flowers with reference to the number of their stamens? How are stamens named with reference to their relative length? 151. How are the stamens placed relatively to the divisions of the corolla? What are their principal directions? 152. Of what parts is the stamen composed? 153. Mention some of the forms assumed by the filament. When the filaments are connected, so as to form one, two, or more parcels, how are they named? 154. Of how many sacs or cells is the anther formed? What is the connective? Does it vary in form? 155. How is the anther named with reference to its mode of attachment? When is an anther said to be introrse or extrorse? 156. Does the anther vary in form? 157. How does its dehiscence take place? 158. Do the anthers ever cohere? 159. Give a general account of the pollen. 160. How is it developed and dispersed? 161. What is meant by hypogynous, perigynous, and epigynous, insertion of the stamens? 162. Is the analogy between stamens and leaves very obvious?

CHAPTER XIV.

THE PISTIL.

163. *Nature of the Pistil.*—The central organ of the flower is composed essentially of a *Germen* or *Ovarium*, containing the young *Seeds* or *Ovules*, and of a *Stigma*, or fleshy extremity, which may either be seated directly upon the ovarium, or elevated upon a stalk, named the *style*. These parts collectively constitute the *Pistil*, *Pistillum*, of which Fig. 177, Pl. XIV., represents the pistil, *a;* the style, *b;* the stigma, *c.* The pistil may

be simple or compound: in the former case, it is formed of a single leaf named the *Carpel, Carpellum;* in the latter, of several carpels. Each carpel is an organ analogous to a leaf, folded inwards upon its midrib, so that its two edges, coming into contact, cohere, forming the *placenta,* to which the ovules or young seeds are attached.

164. *The Ovarium.*—Considering the single pistil, then, as a leaf folded inwards upon itself in the direction of the axis of the plant, we find that the ovarium or germen is the lamina, the style an elongation of the midrib, and the stigma the humid secreting apex of the latter. This appears obvious from the examination of what takes place in the double cherry-flower, in which the pistil is altered so as to assume the appearance of one of the common leaves of the tree, having the two sides of its upper or inner surface brought together, its margins in contact, its midrib prolonged, and its tip somewhat enlarged and discoloured. For the most part, the carpel is sessile, but in some cases it is elevated upon a stalk, named the *thecaphore,* which is thus analogous to the petiole of the leaf. When the pistil is composed of several leaves or carpels, it is said to be compound or multiple. In this case the carpels are usually arranged so as to form a single whorl, but sometimes so as to present several whorls placed within each other.

165. *Arrangement of Carpels.*—A pistil composed of a whorl or whorls of carpels, may present the following arrangements:—1. The carpels are *whorled round a real axis,* formed by a prolongation of the pedicle; to this they adhere by their inner angle, as in Mallow and Spurge. 2. They are *whorled round a central column,* to which they are suspended, being attached merely by the summit of their inner angle, as in Geranium. 3. They are *whorled round the summit of the axis,* but

are erect, and adhere by the *base* of the inner angle, as in Aconite, in which the axis is so short as to be imperceptible. But the axis is elongated, and the whorl raised in Rue. 4. They are *disposed in a spike around the central axis* in Ranunculus and Magnolia. The axis may be very short or rounded, and the carpels collected into a compact head, as in Blackberry and Raspberry. 5. They are *scattered upon the walls of the torus* adhering to the calyx, as in Rose—the only case, perhaps of this kind of arrangement. In all these cases, several carpels are supposed to exist, and this is the normal state; by abortion, however, or cohesion, they may be reduced to unity, really or apparently.

166. *Form and Relations of the Ovary.*—Although generally *ovoidal* or *roundish,* the ovarium assumes a variety of forms, being *trigonal, tetragonal, pentagonal, lobed, depressed,* or more or less elongated and compressed. It is generally *free,* or not adherent to the calyx, as in the Hyacinth and Tulip; but sometimes it is united with the tube of the calyx, so that its summit alone is free, as in the Apple and Hawthorn. In the former case it is said to be *superior,* with relation to the perianth; in the latter, *inferior.* Sometimes the ovary is adherent in part of its extent, and free in the upper part; as is seen in the genus *Saxifraga.* When several ovaries are disposed upon the inner walls of a tubular calyx, they are said to be *parietal,* as in *Rosa.* The compound ovary often presents the appearance of a single body, divided internally by partitions, Pl. XIV., Fig. 179.

167. *Dissepiments of the Ovary.*—As a single carpel is analogous to a leaf, it never has an internal dissepiment or partition, properly so called, although it may present membranous laminæ of various kinds. But when several carpels unite to form a compound ovary, they, being leaves folded inwards upon themselves, constitute

a body which, on being cut across, generally presents a number of dissepiments. These partitions are always longitudinal or vertical, and are uniformly equal in number to the carpels. As the placenta is the enlarged margin of the carpel, the dissepiment is always connected with it; hence, a partition in an ovary not connected with the placenta, is not a true dissepiment. The dissepiments may alternate with the placentæ, when the latter are formed by the cohesion of the two margins of the same carpel; or they may be opposite to the placentæ, when the latter are formed by the cohesion of the margins of contiguous carpels. Sometimes, in a compound ovary, the united sides of the carpels do not project so far into the cavity as to meet the axis ; as in the Poppy. In this case, the placentæ are said to be *parietal.* Sometimes also the dissepiments become obliterated, so as to leave the placentæ in the middle, forming what is called *a free central placenta;* as in *Lychnis.*

168. *The Ovules.*—The young seeds, or *Ovula,* are small pulpy bodies, supported by the placenta, and, after impregnation, becoming converted into perfect seeds, capable of germinating. Being attached to the placentæ, or margins of the carpels, they are analogous in position to the buds sometimes found on the edges of leaves ; but their structure is different. The little stalk that supports the ovule is a prolongation of the placenta, and is named the *funiculus* by some, the *podosperm* by others. In almost all cases the ovule is enclosed within the ovarium; but in the Coniferæ and Cycadeæ, in which the carpels are not involute, the ovules are exposed, or *naked.* At first the ovule seems to be of a uniform pulpy nature, but gradually discloses two integuments or sacs open at the top, and a central part named the *nucleus.* The outer sac, or coat, is named *primine,* the inner *secondine,* and the nucleus frequently has a thin coat named the *tercine.*

These three parts are all connected at some point of their surface, and at the apex of the first two is a passage called the *foramen*.

169. *The Style.*—The style is the prolongation of the summit of the ovary which supports the stigma. It may be wanting, and the stigma is then said to be *sessile*, as in poppy. When the ovary is composed of a single carpel, the style is also single; and the number of the styles corresponds with that of the carpels, though, when the carpels are numerous, the styles may be united. 1. With regard to its *direction*, the style is said to be *lateral*, when it arises from the side of the ovary, as in Rose; *basal*, or basilar, when it appears to spring from the base of the ovary, as in Alchemilla; *included*, when it does not project beyond the mouth of the flower, as in Pea; *protruded*, or exserted, when elongated, so as to appear outside the flower, as in Campanula; *vertical*, when standing upright, or in the axis of the flower, as in Lily; *ascending*, when curved upwards, as in Sage; *declinate*, when inclined toward the lower part of the flower, as in Dittany. 2. With regard to its *form*, the style is termed *filiform*, when slender, and of nearly equal thickness in its whole length; *subulate*, or awl-shaped, when tapering towards the end; *trigonal*, when three-sided, as in Lily; *claviform*, or club-shaped, when enlarged upward, as in Snow-flake; *petaloid*, when expanded, thin, and resembling a petal, as in Iris. 3. With reference to its divisions, it may be *simple*, without any division; or *divided*. When the division does not extend far, it is *slit;* when more prolonged, it is *partite*. Thus, it may be *bifid*, or *bipartite; trifid*, or *tripartite*, &c. 4. After fecundation, the style generally falls off, in which case it is said to be *caducous;* or it may remain, and is then called *persistent*.

170. *The Stigma.*—The part which, in fecundation, receives the pollen, is named the *stigma*. It is composed

of cellular tissue, and has its surface generally destitute of epidermis, so that, from transfusion of its fluids, or from secretion, it is usually moist. As already mentioned, it may be *sessile*, or, on the contrary, furnished with a style. In many plants there is only one stigma, while in others there are two, three, five, or many; the number of stigmas being determined by that of the styles. The stigma is generally *terminal*, or placed at the end of the style; but it is sometimes *lateral*, or occupying its side, as in Ranunculus. Considered with reference to various circumstances, it is named *capitate*, or globose, when of a spherical or roundish form, as in Primrose; *hemispherical*, when of the form of a half sphere, as in Henbane; *discoid*, when flat, broad, and like a shield, as in Poppy; *stellate*, when flat, and cut into several lobes, as in Winter-green; *lobed, claviform, subulate, filiform*, &c. With respect to substance, it is fleshy, glandular, or membranous. Its surface may be smooth, velvety, downy, hairy, or feathery.

171. *Adhesion of Floral Organs.*—It has been stated that the sepals frequently cohere; that the petals, and especially the stamens, are very often found in a state of close cohesion, although disposed in several concentric whorls. Cohesion occurs also between neighbouring organs, which differ in nature from one another, as between sepals and petals, between petals and stamens, between stamens and carpels, or between several of these whorls at once. This principle of cohesion furnishes an explanation of the following forms of flowers:—

(1.) *Thalamifloral Arrangement.*—Each whorl of the different organs is distinct from the others at their base, arising separately from the thalamus or torus; in other words, each organ may be detached from the thalamus, without involving the separation of any other organ; there is, in fact, no cohesion of floral organs. Examples

occur in Ranunculus and Magnolia. In all these cases, the stamens are *hypogynous*, and the ovary *superior*.

(2.) *Calycifloral Arrangement.*—The petals and stamens *seem* to grow from the calyx, owing either to the base of these organs cohering with the calyx, or to the torus adhering to the calyx in the part where the stamens and petals grow. In these cases the stamens are termed *perigynous*, as in the Rose. When the ovary adheres to the calyx, the stamens *seem* to be developed from the summit of the ovary, and are called *epigynous*. The ovary is then said to be *inferior*, as in umbelliferous plants.

(3.) *Corollifloral Arrangement.*—The stamens simply cohere by their filaments with the corolla; in these cases the trace of the filament is usually seen upon the tube of the corolla between the lobes. Examples occur in Convolvulus, and the labiate plants.

Recapitulation.

163. Of what parts is the germen or ovary composed? What is meant by Carpel? To what is the carpel analogous? 164. Describe the carpel in a general sense. In what flower is the seed-vessel converted into a leaf? Is the carpel often sessile? What is the Thecaphore? What is a compound pistil? How are the carpels arranged in it? 165. Explain the several arrangements of the whorls of a compound pistil, as they occur in Mallow, Geranium, Aconite, Ranunculus, and Rose. 166. What forms does the Ovary assume? What is meant by a superior or inferior ovary? When are the ovules said to be parietal? 167. Has a simple carpel Dissepiments? Are the dissepiments ever transverse? Is the dissepiment connected with the placenta? What is a parietal placenta? Are the dissepiments ever obliterated? 168. What are the Ovules? How are they connected with the placenta? Are ovules always inclosed in the ovary? What is their structure? 169. De-

fine the Style? Is it always present? May there be more styles than one? When longer than the flower, what is it termed? What directions may it have? Does it vary in form? Is it often divided? How is it named as to duration? 170. What is the Stigma? What forms may it assume? Does it vary as to direction and consistence? 171. Explain the principle of cohesion, as it appears in the thalamifloral, the calycifloral, and the corollifloral arrangements.

CHAPTER XV.

THE RECEPTACLE, DISK, AND NECTARY.

There are certain parts connected with the flower, which, having been only incidentally spoken of in the preceding pages, require to be here described.

172. *The Receptacle.*—It has been stated, at p. 80, that the top of the peduncle generally expands in some degree, so as to form a kind of disk, from which the floral whorls proceed. This part, then, is what is usually termed the receptacle of the flower. But the term receptacle is used by botanists in different senses. Thus it is by some considered as merely the part on which the carpels or fruits are placed, Pl. XVI., Figs. 208, 209, and obtains the names of *Torus* and *Thalamus*. When it rises in the form of a column and bears the stamens, it has been named *Gonophorum*. When elongated and bearing on its summit the petals and stamens, it has been called the *Anthophorum*. When it bears only the ovarium, it has been designated as the *Carpophorum* or *Gynophorum*. In this case it may be either a roundish stalk, when it is named the *Podogynium* or *Thecaphorum*;

or it may be much enlarged and fleshy, with numerous ovaria, when it is named *Polyphorum*. When lengthened into a tapering body, with the styles adhering, it bears the name of *Rostrum*. These terms are perhaps useful in describing particular families.

173. *The Disk.*—Between the base of the stamens and that of the ovary is frequently a fleshy or glandular body, of a yellowish or greenish colour, which, being variously modified, has received various names. Very often it assumes the form of a fleshy ring, surrounding the base of the ovary, when it is named the *Hypogynous Disk.* When formed of several knobs or glands, it has been called the *Epipodium.* Sometimes it presents the appearance of a cup, and is named accordingly a *Cyathiform Disk.* When enlarged and inserted, as it were, under the ovary, to which it forms a kind of receptacle, it is the *Gynobasis.* All these varieties are *hypogynous,* or situated beneath the ovary, or around its base; but when the ovary is inferior, that is, when the perianth adheres to its sides, the disk becomes *epigynous;* as in the plants named *Umbelliferæ,* in which it has been called the *Stylopodium.* Sometimes also it is *perigynous,* or adheres to the sides of the calyx; as in the Almond and Cherry.

174. *Nectaries.*—Linnæus gave the name of *Nectary* to every part of the flower that contains or secretes a saccharine fluid, or even to every supernumerary part of a flower. Thus, the tube of monopetalous flowers, such as *Lamium album,* and the base of the united petals of others, as *Trifolium pratense,* are nectaries. Sometimes it is a prolongation of the calyx, as in *Tropæolum,* Pl. XIII., Fig. 170; or of the corolla, as in *Viola,* and *Antirrhinum,* Fig. 162 ; or a part of the petals, or of some analogous organs, as in *Aquilegia* and *Aconitum,* Fig. 171, 174. The curious fringed scales of *Parnassia,* Pl. XIV., Fig. 175, were also considered of this kind,

as were the disks mentioned in the preceding paragraph. The scales on the claws of the petals of *Ranunculus*, and the pits on those of the Lilies and Fritillaries, are also nectaries; as are the coronal appendages of Narcissus, and the inner minute scales of Grasses. If the term be necessary, it seems expedient to restrict it to those parts which actually secrete honey, the use of which some conceive to be to attract insects, for the purpose of assisting in dispersing the pollen.

175. *Abortion of Floral Organs.*—All the floral organs are liable to imperfect development, or to non-development; in other words, to be *abortive*, and thus to derange, in various ways, the symmetry of the flower. This may occur accidentally, in consequence of injury or disease; or habitually, in conformity with the nature of certain organs in particular species. *Habitual abortion* sometimes occurs during the flowering period, and is perceptible by our senses. Many plants which have a determinate number of carpels when the flower opens, retain only a certain number of them during the period of the ripening of the fruit: a trilocular ovary becomes a bilocular or unilocular fruit, in consequence of the arrested growth of some parts, of the destruction of dissepiments, and of their adhesion to the adjoining membranes. This effect may take place in the bud-state, and escape observation. The traces of these premature abortions are sometimes very discernible. Thus, in the Corollifloræ, there are generally five lobes to the calyx; five to the corolla, alternating with those of the calyx; and five stamens alternating with the lobes of the corolla; but there may be only four stamens, situated normally, while the fifth is replaced by an antherless filament, or an imperfectly-formed anther, or a little gland, or there may be no substitution at all. In these cases, the fifth stamen is more or less abortive, from some arrest of development. The place of the fifth

remains vacant, while the others are in their regular state.

176. Abortion occurs more frequently, as the organ is more distant from the circumference of the flower; hence the *calyx* is rarely abortive ; the tube is, however, frequently reduced to the condition of very thin membrane, and the limb consists merely of hairs, or teeth, as in Compositæ. The lobes are often wanting in Umbelliferæ. The *corolla* is entirely wanting in Capparideæ, in some Caryophylleæ, and in many other cases. The absence of the *stamens* or *pistils* is the more remarkable, that their function is of great importance. Flowers sometimes occur in the same species and on the same stalk in which one of these organs is imperfectly developed—in which the stamens have no pollen, or the ovaries no ovules. Or one of these organs may fail completely; when this is constant, the plant is called *unisexual*, as contradistinguished from perfect or *hermaphrodite* plants.

177. *Monochlamydeous Flowers.*—Many plants have only one envelope to their flowers. This envelope is single in some dicotyledons, as daphne ; double in most monocotyledons, as in liliaceous plants. The term *perianth* has been already noticed, as applied to this envelope ; another term is *perigonium*, which merely signifies the envelope surrounding the sexual organs ; when there is only one whorl, the perigonium is *simple;* when there are two, it is *double.* Deviations from symmetry and cohesions occur here, as in the other forms of floral apparatus.

178. *Multiplication of Floral Organs.*—It has been observed that parts of a flower are sometimes abortive ; on the other hand, the parts are sometimes multiplied under certain circumstances. This is in great measure

the origin of what are called "double" flowers. Multiplication of floral organs may occur in two ways :—

1. The *number of entire whorls* may be multiplied.

2. The *number of pieces of a whorl* may be multiplied.

These multiplications may occur in an individual accidentally, or they may be constant in varieties which have been carefully cultivated.

(1.) Entire whorls of *bracts* are added in *dianthus caryophyllus imbricatus.* Instead of one pair there may be from fifteen to twenty pairs, situated at right angles to each other, and imbricated, sometimes preventing the growth of the flower. Entire whorls of *perigonium* are added in a variety of white lily, although the stamens are developed in the interior. The *corolla* is multiplied in *datura fastuosa ;* two or three whorls are placed concentrically within one another. In plants with numerous *stamens*, the number of whorls varies considerably ; and so with *carpels*, when they are numerous. This kind of multiplication deranges the normal symmetry of flowers; but it is worthy of remark that supernumerary whorls of petals, stamens, and carpels are always alternate with the series immediately exterior to them.

(2.) The number of parts constituting a whorl may be multiplied accidentally. Colchicum may have seven or eight lobes, seven or eight stamens ; rue or syringa may have four or five pieces. These multiplications are sometimes merely apparent, and are owing to the solution of organs which are naturally in a state of cohesion. On the other hand, a single organ may be replaced by a bunch of similar organs: a fasciculus of petals occurs in the place of each petal in a *primula* described by Decandolle.

179. "*Double*" *Flowers.*—Flowers with numerous whorls, as those of nymphæa, pæonia, &c., are probably

produced by the tendency of these species to *multiply* their organs. Or they may result from *transformation:* flowers with five stamens and five petals may have ten petals in two whorls; here, the stamens have been transformed into petals. Sometimes the anthers, at other times the filaments, undergo this change; but it is generally the filament, which in such cases loses its anther, and becomes plane and coloured like a petal. When the anther is transformed, it changes into the shape of a *horn:* thus, there are two garden varieties of *aquilegia vulgaris*—the one named *stellata,* from transformation of the filaments; the other *corniculata,* from transformation of the anthers into *horns.*

Recapitulation.

172. What is commonly meant by the Receptacle? When is it named the Torus or Thalamus? What is the Gonophore, Anthophore, Carpophore, Thecaphore, Polyphore? 173. Where is the Disk situated? When is it hypogynous, epigynous, and perigynous? 174. What is meant by the term Nectary? What parts of plants secrete honey? 175. What is meant by abortion of floral organs? How may this principle operate, habitually, in the case of carpels and of stamens? 176. What is the comparative frequency of abortion in the several whorls of the flower? 177. What are Monochlamydeous flowers? What is the perigonium? 178. In what two ways does multiplication of floral organs occur? Is any order observable in cases of multiplication of entire whorls? On what principles may the multiplication of portions of a whorl be explained? 179. What is meant by double flowers? On what principles is this mode of multiplication explained?

CHAPTER XVI.

THE FRUIT.

180. *General Idea of the Fruit.*—The *Fruit*, *Fructus*, Pl. XIV., Fig. 179, 180, 181, 182, is the ovary or germen arrived at maturity. Frequently there are connected with it persistent bracteæ, calyces, or corollæ, enlarged, and either dry or pulpy, which may also be considered as forming part of it. It is composed essentially of two parts, the *pericarp* and the *seed*, the former enclosing the latter. By this character a small fruit may be distinguished from a seed, as well as by its often having on some part of its surface some trace of the style or stigma. Many fruits, as those of the natural families of the *Umbelliferæ*, *Labiatæ*, *Boragineæ*, and *Grasses*, were formerly considered as naked seeds, but are now known to consist of seeds surrounded with a pericarp ; the only naked seeds known being confined to the families of *Coniferæ* and *Cycadeæ*.

181. *The Pericarp.*—The part of the fruit which immediately invests the seed or seeds, and originally formed the ovarium, is the *Pericarp*, *Pericarpium*. The *base* of the pericarp is the part by which it is attached to the peduncle, and its *apex* is indicated by the remains of the style or stigma. The pericarp varies extremely in size, thickness, and texture ; being from a twelfth of an inch to two feet or more in diameter, delicately membranous, spongy, succulent, fibrous, cartilaginous, woody, or bony. It is always formed of three parts : the *Epicarp*, *Mesocarp*, and *Endocarp*.

182.—1. The *epicarp* is the external membrane or skin of the fruit ; in the Cherry, Pl. XV., Fig. 183, and

in the Pea, Pl. XIV., Fig. 182, it is the outermost delicate covering or cuticle. It may readily be detached, as a velvety skin, in the Peach, while in the Nectarine and the Apricot it adheres to the mesocarp. 2. The *mesocarp* is the layer which lies immediately beneath the epicarp ; it is sometimes so thin as to be hardly distinguishable ; in other cases it is thick, fleshy, or fibrous. It is the dry fibrous part of the Almond, surrounding the shell ; in the Peach, Apricot, and Cherry it is the fleshy, eatable portion, and in these cases it is called *sarcocarp*. 3. The *endocarp* is the innermost membrane or shell, being, in the Pea, a thin, transparent coating, and in the Peach, Apricot, and Cherry, the bony part of the "stone." 4. These three portions of the pericarp may adhere to one another in different degrees : in the Peach, the three parts are easily separated from one another ; in the Nectarine, the Apricot, and the Almond, the epicarp always adheres to the mesocarp, and this latter separates spontaneously from the endocarp. In the Apple, Pl. XV., Fig. 184, the epicarp is formed by the cuticle of the enlarged tube of the calyx, the mesocarp is the pulpy mass formed by its parenchyma, and the endocarps are the thin dry walls of the cavities containing the seeds. The endocarps are here popularly called the *core*.

183. *Structure of the Pericarp*.—A fruit may be composed of a single carpel or pericarp, or of several pericarps, either separate or united. When the carpels are distinct, the fruit is said to be *apocarpous;* when coherent, *syncarpous*. The structure of a single pericarp is well illustrated by the common Pea, Pl. XIV., Fig. 182, which is a modified leaf, folded inwards, with the seeds attached to the margins, which are united and thickened, to form the placenta. When several carpels cohere, each carpel generally forms a complete cell, and the fruit may thus

be *bilocular*, *trilocular*, *quadrilocular*, *quinquilocular*, or *multilocular*, one-celled, two-celled, &c. Sometimes, however, when the ovary is thus divided into several distinct cavities, it undergoes modifications in the progress of its development, and may ultimately present a single cavity, or one divided by partial partitions. The walls of the cells are named *dissepiments*, and are formed of the sides of two contiguous carpels. The fruit of the Stramonium, Pl. XIV., Fig. 179, has four cells, formed by four imperfect dissepiments. The Apple has five cells, formed of five carpels enveloped in a pulpy sarcocarp, and inclosed in an epicarp composed of the calyx, Pl. XV., Fig. 184.

184. *Dehiscence of Fruits.*—The cohesion of the margins of the carpel constitutes a *suture* or seam; the suture is said to be *ventral* or *seminiferous*, the former term denoting that its position is opposite to the dorsal vein of the carpel; the latter denoting the development of the seeds along the two sides of this line. Fruits are said to be *dehiscent* or *indehiscent*, according as their carpels open or remain closed, at the period of maturity. The pieces which separate from one another in dehiscence are called *valves*. The suture, the dorsal vein, and the two valves are familiarly exhibited in the Pea. Dehiscence is longitudinal or transverse—most com-

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Description of Plate XIV. Stamens, Pistils, and Fruit. Fig. 174. Pair of Nectaries, in *Aconitum*. Fig. 175. Fringed Nectaries of *Parnassia*. Fig. 176. A Stamen: *a*, the filament; *b*, the anther. Fig. 177. A Pistil: *a*, the germen; *b*, the style; *c*, the stigma. Fig. 178. Capsule of a *Mesembryanthemum*, open and shut. Fig. 179. Transverse section of the Capsule of *Datura*, showing the partitions and columellas. Fig. 180. A siliqua or Pod. Fig. 181. A silicula or Pouch. Fig. 182. A Legume.

monly the former. 1. Longitudinal dehiscence is called *septicidal,* when it takes place along the ventral sutures: the dissepiments or *septa* of the contiguous carpels are then separated from one another, as in Rhododendron. It is *loculicidal,* when it takes place along the dorsal veins: the loculi or cells are then divided at their backs, as in Lilac. Or it may be *septifragal,* when the backs of the carpels separate from the septa, which adhere to the axis, as in Convolvulus. 2. Transverse dehiscence is called *circumscissile,* when the pericarp is divided all around by a transverse separation, as in Henbane and Pimpernel. Many pericarps open irregularly; in some the seeds escape by pores or small valves which open at the upper extremity, as in the pericarp of Poppy and of Snap-dragon.

185. *Classification of Fruits.*—There are three large classes of fruits; viz. *simple* or apocarpous fruits, or the result of free carpels in one and the same flower; *compound* or syncarpous fruits, formed by the cohesion of several carpels in the same flower; and *aggregate* or polyanthocarpous fruits, formed by the cohesion of several fruits, of different flowers.

DESCRIPTION OF PLATE XV. Fruit. Fig. 183. A Drupe. Fig. 184. A Pome or Apple. Fig. 185. A Berry. Fig. 186. A kind of Berry formed of an aggregation of little Drupes, and called an Etærio. Fig. 187. Berry of *Passiflora suberosa.* Fig. 188. Cone or Strobilus of the Larch. Fig. 189. Capsule of a Moss, *Splachnum,* with its fleshy base or apophysis, *a,* and its fringe or peristome, *b.* Fig. 190. Barren flower of a Moss, after Hedwig, magnified. Fig. 191. Supposed stamens with the pollen issuing, and the jointed filaments. Fig. 192. Fertile flower of a Moss, consisting of numerous pistils. Fig. 193. Germinating seed of *Gymnostomum pyriforme.* Fig. 194. The same more advanced.

186. Simple or Apocarpous Fruits.—Of fruits simple in structure, and of which only one series is produced by each flower, the following are the most common :—

1. *Follicle, Folliculus.* A dry pericarp, having the appearance of a folded leaf, and opening by the ventral suture, so that it may be considered as composed of a single valve, along the margins of which the seeds are disposed; as in *Vinca, Caltha,* and *Ranunculus.*

2. The *Legume, Legumen.* Pl. XIV., Fig. 182. A pericarp formed of a single carpel, or leaf folded upon itself, with the edges adherent, opening longitudinally into two valves, by the ventral suture and the dorsal vein simultaneously. The Legume differs from the Follicle only in this latter circumstance. Sometimes, however, it is indehiscent. When a Legume is contracted in the spaces between the seeds, or when transverse partitions are there formed, it is named a *Lomentum.* Examples of the Legume are seen in the Pea, the Bean, Laburnum, and other plants with papilionaceous flowers. The Lomentum occurs in Ornithopus and some Acacias.

3. The *Nucula.* Pl. X., Fig. 126 ; Pl. XVI., Fig. 201. A hard pericarp, of a horny or bony texture, indehiscent, and containing a single seed, to which it is not closely attached ; as in *Lamium* and *Borago.* It is also named *Nut, Nux ;* but is not what is commonly called by that name. The fruit of the Strawberry is a collection of minute nucules, acini, or nuts, upon a convex fleshy torus. The fruit of the Rose is an analogous collection of nuts placed within a torus, which coheres with the tube of the calyx, and becomes fleshy. This particular fruit is termed *Cynorrhodon.*

4. The *Drupe, Drupa.* Pl. XV., Fig. 183. An indehiscent fruit of which the pericarp is thin, the mesocarp very thick and pulpy, the endocarp hard. The seed is single, although in the early state there are two,

one of them usually becoming abortive. Examples are seen in the Cherry, Peach, Plum, and Apricot. The fruit of the Raspberry and the Blackberry consists of numerous minute drupes, placed on a convex torus. This arrangement is sometimes called *Etærio*, Pl. XV., Fig. 186.

187. COMPOUND OR SYNCARPOUS FRUITS.—A compound fruit is one composed of several united ovaria. A fruit of this kind, as indicated by having several styles or stigmas, may be simple, from the abortion of some of its carpels, and then assumes the appearance of a simple fruit.

5. The *Caryopsis*. This kind of fruit, which is peculiar to the Grasses, is one-celled, one-seeded, indehiscent, dry, with the pericarp so united with the seed as not to be distinguishable from it. From having two or more stigmas, the ovarium may be supposed to be of a compound nature, although it never has more than one ovule.

6. *Achenium*, Pl. XVI., Fig. 204. A one-seeded, one-celled, indehiscent fruit, with the pericarp not adherent to the seed. Having two or more stigmas, the ovarium may, like the last, be supposed to be compound, although there is never more than one ovule. All the plants forming the natural order of *Compositæ* have fruits of this kind. The *Diachemium*, Fig. 206, composed of two achenia, is the fruit of the *Umbelliferæ*.

7. *Carcerulus*. A many-celled fruit; the cells dry, indehiscent, few-seeded, cohering round a common axis; as in *Malva*.

8. The *Samara*. A two-celled fruit; the cells dry, indehiscent, few-seeded, elongated into membranous expansions; as in the Ash, Elm, and Sycamore.

9. The *Siliqua*. Pl. XIV., Fig. 180. An elongated, two-valved, many-seeded pericarp, having the seeds attached to two lateral placentæ, and a dissepiment formed

by a membrane, which is a prolongation of the endocarp; as in the Cabbage and Mustard. The *Silicula* differs merely in being proportionally broader; Pl. XIV., Fig. 181. These fruits characterise the Cruciferous family of plants.

10. The *Capsule, Capsula.* Pl. XIV., Fig. 178. A dry, dehiscent, many-seeded, one-celled, or many-celled pericarp; as in *Primula* and *Stellaria.* Pl. XIV., Fig. 179, exhibits a transverse section of the capsule of Stramonium, with its four cells, central placentation, and numerous seeds arranged round one of the placentæ. The fruit of Henbane, Pimpernel, and Lecythis, is a capsule, but it opens transversely, and has hence received the name of *Pyxidium.*

11. The *Acorn, Glans.* A one-celled fruit, with one or few seeds, indehiscent, hard and dry, with its base enveloped by an involucrum or cupule. The fruit of the Oak, Hazel, and Chestnut, are of this kind.

12. The *Gourd, Pepo.* A one-celled, indehiscent, fleshy fruit, with numerous seeds attached to parietal pulpy placentæ; as in the Melon and Cucumber.

13. *Berry, Bacca.* Pl. XII,, Fig. 185. An indehiscent, many-seeded, pulpy fruit; as in the Gooseberry and Currant. The use of this term has been extended to almost all fruits which are semi-liquid interiorly, and indehiscent. In this sense it is opposed to the term *Capsule.* It is said, for instance, that the Grape is a berry, resulting from a free ovary, while the Gooseberry is an adherent fruit.

14. The *Apple, Pomum.* Pl. XII., Fig. 184. A fruit consisting of several membranous or cartilaginous carpels, containing few seeds, and embedded in a fleshy mass, formed by an enlarged calyx; as in the Apple and Pear.

15. The *Hesperidium.* A fleshy fruit, with a thick

envelope, and divided internally into several cells by membranous dissepiments; as in the Orange and Lemon.

188. AGGREGATE OR POLYANTHOCARPOUS FRUITS.—In these the floral envelopes or bracteas are enlarged and thickened.

16. The *Cone.* The cone, or strobile, is an enlarged catkin, the scales of which bear naked seeds. It is an assemblage of sessile fruits, each consisting of a pericarp, in the form of a convex scale, and of seeds situated at the base of the pericarp, as in the Pine and the Fir. In some cases the scales cohere, as in Juniper.

17. The *Syconus.* A fleshy, concave receptacle, enclosing, more or less completely, some very minute, distinct fruits, proceeding from a multitude of flowers, as the Fig.

18. The *Sorosis.* A collection of carpels, of several flowers, cohering by the enveloping parts of the floral apparatus, of the bracts, and fleshy floral axes, which adhere to one another, as in the Bread-fruit and the Pine-apple.

189. *Terms of Rarer Occurrence.*—According to the number of seeds contained in a fruit, this is termed *oligospermous* or *polyspermous.* The former contains few, generally a determinate number of seeds; in the latter, the number is large and indeterminate. Fruits in which the pericarp is very thin, and adheres closely to the seed, are called *pseudospermous,* as in the Gramineæ, Labiatæ, Compositæ, &c.

In addition to the names of fruits, arranged and described above, the following may be noticed :—

19. *Utricle. Utriculus.*—A simple or apocarpous, indehiscent, membranous pericarp, elastic, sometimes bursting transversely at its base, rather in consequence of a shock, than by natural dehiscence, as in Amaranth.

20. *Amphisarca.*—A compound or syncarpous, inde-

hiscent pericarp, rather hard than fleshy, containing seeds in the cells surrounded with pulp, as in Crescentia and Adansonia.

21. *Nuculanium.*—A compound or syncarpous, indehiscent fruit, with fleshy mesocarp, and pulp in the cells; it is in fact a berry, not adherent to the calyx. The name is little used, the term berry being often employed for it, as in the grape.

22. *Conceptaculum.*—A compound or syncarpous, dehiscent fruit, formed of two follicles cohering at their back. The name of *double follicle* is often used, as in several Asclepiadaceæ.

23. *Diplotegia* or *Adherent Capsule.*—A compound or syncarpous, dehiscent fruit, consisting of a capsule cohering with the calyx or perigonium, as in Campanula. These fruits are commonly called *Capsules,* owing to the extension of the term by the old botanists, who had not discovered the principle of the cohesion of organs. In description, it is right to say whether the ovary is free or adherent, and hence, when a capsule is spoken of, it is at once understood whether it is adherent, or a true capsule.

24. *Cremocarpium.*—This is the compound or syncarpous, indehiscent fruit of the Umbelliferæ, Araliaceæ, &c., consisting of two or more carpels cohering with the tube of the calyx, and interiorly with the single seed. At a certain period, the carpels, called *mericarps,* when there are two, separate from below upward, and burst the tube of the calyx, a portion of which remains attached to the back of each. This fruit is also termed *diakenium, pentakenium, polakenium,* according to the number of akenia composing it.

25. *Balausta.*—A compound or syncarpous, indehiscent, multilocular, adherent fruit, with a hard envelope; its seeds surrounded by pulp without losing their points

of attachment. The cells are superposed, owing to the presence of two whorls of carpels, which adhere, the one above the other, to each other, and to the tube of the calyx—a circumstance which can be ascertained only in the flower-state. It occurs in the Pomegranate.

Recapitulation.

180. What is meant by the term fruit? Of what parts does it essentially consist? How are minute fruits in some cases distinguished from seeds? Are there any naked seeds? 181. What is the pericarp? How are the base and the apex of the pericarp determined? Into what parts is the pericarp divisible? 182. Describe the epicarp, the mesocarp, and the endocarp of different fruits. Explain their modes of cohesion with one another. 183. Distinguish between apocarpous and syncarpous fruits. What is meant by a multilocular fruit? What are dissepiments? Explain the structure of the fruit of the stramonium and of the apple. 184. What is a suture? Distinguish between the ventral suture and the dorsal vein of a carpel. What is meant by dehiscence? Explain and give examples of septicidal, loculicidal, septifragal, and circumscissile dehiscence. What are the valves of a carpel? 185. Describe the three classes of fruit. 186. What are the principal simple or apocarpous fruits? Describe the follicle. In what respect does the legume differ from the follicle, and from the lomentum? What is the nucule? Explain the structure of the fruit of the strawberry and of the rose. What is a drupe? Describe the fruit of the raspberry and of the blackberry. What is the etærio? 187. What is a compound fruit? In what cases does it assume the appearance of a simple fruit? Describe the caryopsis and the achenium, the carcerule, and the samara. Distinguish between the siliqua and the silicula. Describe the Capsule, and state in what respect it differs from the berry. Describe the Glans, the Pepo, and the Berry; the Pome and the Hesperidium. 188. What are aggregate Fruits? Describe the

Cone, the Syconus, and the Sorosis. 189. What terms are applied to fruits with reference to the number of their seeds? What is the Utricle? What is the Amphisarca? Describe the Nuculanium and the Conceptaculum. What is the Diplotegia? In what does it differ from the true capsule? Explain the Cremocarpium. Give the name and structure of the fruit of the Pomegranate.

CHAPTER XVII.

THE SEED.

190. *Nature of the Seed.*—The fecundated and matured ovule is the *seed*, a body inclosed within the pericarp, and containing an organized embryo, which, on being placed in favourable circumstances, is developed into an individual, similar to that from which it derived its origin. The reproductive organs of flowerless plants, as sea-weeds and fungi, differ in structure, and in their mode of germination; and are not considered as true seeds, but are named *sporules.* The seed is attached to the placenta by a small pedicle or *umbilical cord,* sometimes called the *podosperm.* In some plants this cord is unusually expanded into a partial covering of the seed, called the *arillus;* this body constitutes the *mace,* which irregularly envelopes the Nutmeg. The seed consists essentially of an external skin, called *spermoderm,* or perisperm, and a *nucleus,* or kernel.

191. *Spermoderm, or Perisperm.*—The spermoderm, or *skin* of the seed, consists, in a general sense, of three envelopes: the exterior one is the *testa,* the interior the *endopleura,* and the intermediate the *mesosperm.* These distinctions, adopted for the purpose of establishing an

analogy between the spermoderm and the leaf, are not commonly appreciable; if parts of the ovule, corresponding to them, as primine, secundine, and tercine, really exist in the seed, their conditions are usually masked by cohesion. The surface and the form of seeds vary considerably. The seed separates from its support, leaving a scar, called the *hilum*, cicatricula, or umbilicus; this part is sometimes very small, but in some cases it is remarkably large, as in the Horse-chestnut, in which it is of a whitish colour. This part always indicates the true base of the seed. The centre of the hilum, through which the nutrient vessels pass into the interior, is called the *omphalodium*. At the summit of some seeds, as of the Orange and the Almond, a brown spot is observed, formed by the union of certain vessels which proceed from the hilum; this spot is the *chalaza*, and it is connected with the hilum by a bundle of vessels which pass along the face of the seed, and is termed the *raphé*.

192. *Nucleus or Kernel.*—The nucleus of the seed is the body contained within the spermoderm, and it consists of the embryo and albumen, or of the embryo alone; the latter being the essential part of the nucleus. 1. The *albumen*, when present, incloses the embryo; it varies considerably in consistence, being fleshy, farinaceous, oily, horny, or bony. In many plants, as the Grasses, the albumen constitutes a very nutritious fecula or farina. It sometimes exists in very small quantity; in other cases it is abundant, and exceeds the embryo in size. An important distinction derived from the presence or absence of albumen, is that of albuminous and exalbuminous seeds. 2. The *embryo* is the young plant, and it is composed of three parts, viz., the *radicle*, the *plumule*, and the *cotyledon*, or cotyledons.

193. *The Radicle.*—The radicle is a simple, minute root, Pl. I., Fig. 4, *f*, commonly thin and pointed, form-

ing one extremity of the embryo, and, when germination takes place, giving rise to the root. The direction of the radicle determines the position of the embryo, as it always points toward a small hole, the *foramen*, in the testa or outer coat of the seed. As this aperture may be placed near the hilum, or at a distance from it, or even on the opposite side, the embryo will be *erect*, *inverse*, or *transverse*. Sometimes the radicle is external and exposed; sometimes covered and concealed by a body or sheath named the *coleorrhiza*, which it bursts in germinating; and less frequently incorporated with the albumen. These circumstances have given rise to a division of plants into *Exorrhizous*, *Endorrhizous*, *Synorrhizous*, with which correspond the *Dicotyledonous*, *Monocotyledonous*, and *Polycotyledonous* plants, the last being the Coniferæ and the Cycadeæ.

194. *The Plumule.*—The plumule is the young stem, which is to be developed into the stem, leaves, and flowers of the new plant. It is sometimes scarcely perceptible in the seed; in other cases it is as long as the radicle. It consists of two parts—the *caulicle*, or little stem, and the *gemmule*, or little bud. These parts are distinctly seen in Pl. I., Fig. 4, 9, in which the seed has germinated ; here the spermoderm is ruptured, the radicle is represented as descending, the plumule as ascending, with its gemmule at the summit, composed of the rudiments of all the parts which are to be developed in the air.

195. *The Cotyledons.*—The *cotyledonary body* is sometimes simple and undivided, thus constituting a single cotyledon, as in Grasses and other endogenous plants; sometimes formed of two cotyledons united at their base. Plants whose embryos have a single cotyledon are named *monocotyledonous*, while those which have two cotyledons form the class of *dicotyledonous* plants. Sometimes there

are more than two cotyledons, as in the Pines and other Coniferæ, in which the number varies, in different species, from three to twelve. Pl. I., Fig. 2, represents the seed of *Pinus Cembra*, having about twelve cotyledons; and Fig. 3, a young plant of the Norfolk Island Pine, which has four cotyledons. In plants destitute of albumen, the cotyledons are generally thick, and in those furnished with that organ, thin. It is therefore probable that they supply nourishment to the young plant. After germination, they become thinner, are raised to the surface, acquire a green colour, and become the first or seminal leaves, as in Lupine and Sycamore; in this case they are said to be *epigeal*. But sometimes they remain under ground, and are named *hypogeal*, as in the Bean. The cotyledons are frequently straight, but they may also be arcuate, spiral, undulated, and of various forms. They are usually placed face to face, but are often separated to some distance. When folded with their back to the radicle, they are said to be *incumbent*, and when their edges are presented to that part, they are *accumbent;* these peculiarities occur in cruciferous plants: the cotyledons are incumbent in the Stock, accumbent in the Wall-flower. In the Cabbage, they are folded upon themselves, and are then said to be *conduplicate*.

196. *Dicotyledonous Embryo.*—In the embryo, of which the Cotyledonary Body has two distinct lobes, the radicle is cylindrical or conical, exposed, protruded, and elongates at germination so as to become the true root of the plant. The two cotyledons are attached to the caulicle at the same height, opposite to each other, and are generally thick. The gemmule is contained between the cotyledons, by which it is more or less concealed. Sometimes, however, the two cotyledons are intimately united, as in the Horse-Chestnut; or they are increased in number, as in the Coniferæ; or are accidentally ab-

sent, as in Cuscuta. In germination, the radicle elongates and becomes the root, the cotyledons rise above the ground, and are converted into leaves, and the gemmule unfolds itself into the stem, foliage, and flowers.

197. *Monocotyledonous Embryo.* — In monocotyledonous plants the embryo is generally a cylindrical or oblong, undivided, homogeneous body, in which there is no obvious distinction of radicle, plumule, or cotyledons. In germination, the upper end swells and remains within the perisperm, while the lower elongates, and emits one or several radicles, shooting downwards, and a slender green body, protruding from its upper portion, and rising into the air. The upper part remaining within the testa is the single cotyledon; the radicle is at first enclosed in the coleorhiza, which it bursts; and the gemmule, also contained in the interior of the cotyledon, is composed of leaflets enclosing each other, the outermost usually covering the rest.

198. With reference to the foregoing statements, it will be advisable for the reader to examine a few seeds. 1. In the *Orange*, the seed is pendulous, occasionally containing more than one embryo. The *raphé* and *chalaza* are distinctly marked. The *embryo* is straight; the *cotyledons* thick and fleshy; the *plumule* conspicuous. 2. In the *Almond*, the seed is suspended, in consequence of the cohesion of an umbilical cord, arising from the base of the ovary, with its side. The *embryo* is straight, the radicle pointing to the hilum. The *cotyledons* are thick; *albumen*, none. 3. In the *Nutmeg*, the seed is nut-like, enveloped in an arillus, or the mace. *Albumen*, between fatty and fleshy, of a variegated appearance, termed *ruminate*. The *embryo* is small; *cotyledons*, foliaceous; the *plumule* conspicuous.

199. *Classification.*—As it has already been stated that the exogenous stem usually corresponds with a reti-

culate leaf and a flower with five or four petals, and the endogenous stem with a parallel-veined leaf and a flower with three petals, it may here be added, that the dicotyledonous embryo corresponds with the former, the monocotyledonous with the latter class. Hence, a dicotyledonous plant is, in other terms, an Exogen; a monocotyledonous, an Endogen.

Recapitulation.

190. Give a general account of the Seed. What is a Sporule? How is the seed attached to the placenta? What is the Arillus? Of what parts is the seed composed? 191. Describe the Spermoderm. What is the Hilum, the Omphalodium, the Chalaza, and the Raphé? 192. Of what is the Kernel composed? Is the Albumen always present? What are the position and general characters of the Albumen? What parts enter into the composition of the Embryo? What different positions may it assume? 193. What names are given to plants with reference to the position of the radicle? 194. What is the Plumule? Into how many parts is it divided? 195. Give an account of the Cotyledonary Body. What is meant by Monocotyledonous and Dicotyledonous? Are there ever more than two Cotyledons? Do the cotyledons vary in form and direction? Why are they distinguished into epigeal and hypogeal? When are they said to be incumbent, accumbent, and conduplicate? 196. Describe the Dicotyledonous Embryo. 197. Describe the Monocotyledonous Embryo. 198. Describe the seed of the orange, of the almond, and of the nutmeg. 199. State the relations subsisting between the structure of the seed and that of the leaf, of the flower, and of the stem.

CHAPTER XVIII.

FLOWERLESS PLANTS.

200. *General Remarks.*—The preceding chapters have been devoted to two large classes of plants, viz., the dicotyledonous or exogenous, and the monocotyledonous or endogenous ; all the plants composing these two classes are furnished with flowers. There remains another large class, in which there are no cotyledons or flowers. These are commonly called *cryptogamic* plants, owing to the concealed nature of their organs of reproduction, and as distinguished from both the other classes, which, from having these organs manifest, are called *phanerogamic.* They are also called *cellular* plants, owing to their being formed of cellular tissue only, or of cellular tissue and ducts. Their reproductive organs, which are termed *spores* or sporules, are minute granular bodies, having no distinct parts, but germinating from any point of their surface. Flowerless plants form the lowest series of the vegetable kingdom; and it is in some of these that a transition is exhibited to some of the simplest forms of animals. The principal families of flowerless plants are Ferns, Mosses, Lichens, Fungi, and Algæ.

201. *Ferns.*—The *Ferns* are the largest of those plants which are destitute of floral organs. They consist of a number of leaves, named *Fronds,* attached to a stem, which is either a subterranean rhizoma, or rises, like the trunk of a tree, to the height sometimes of fifteen or twenty feet. Their stem is formed by the cohesion of the bases of the petioles round a cellular axis. Their fronds are sometimes simple, but more frequently divided,

or variously decompounded, and in vernation are rolled up. The reproductive organs consist of *Thecæ*, or minute capsules, aggregated into little masses named *Sori*, of various forms, and variously arranged on the back of the frond, or along its margins. The thecæ are either pedicillate, and surrounded by an elastic ring, Pl. XI., Fig. 145, or sessile, and destitute of a ring. When the sori originate beneath the cuticle, they force it up in the form of a delicate covering, called *Indusium* or *Involucrum*, Pl. XI., Fig. 144. The *Sporules*, or reproductive germs, are extremely small, and disposed without order within the thecæ. These plants approach in form, as well as structure, to the flowering plants, especially the *Cycadeæ* and *Coniferæ*.

202. *Equisetaceæ.*—These are herbaceous perennial plants, with simple or branched, generally hollow, longitudinally striated stems, jointed at intervals, and having sheaths at the joints. The organs of reproduction are arranged in a terminal spike or catkin, composed of peltate scales, on the lower surface of which are *Capsules* or thecæ, filled with *Granules* of two kinds, some very minute, others larger, and enfolded by four elastic filaments. These larger granules are the reproductive *Sporules*.

203. *Marsileaceæ.*—These are small aquatic plants, of which the reproductive organs are a kind of leathery *Involucres*, with one or more cells, containing *Sporules*, and placed at the base of the leaves.

204. *Lycopodiaceæ.*—These are intermediate in appearance between Mosses and Ferns. They are either stemless, with erect subulate leaves, or they have creeping stems and imbricated leaves. The organs of reproduction are sometimes small, globular, or reniform single-celled *Capsules*, containing numerous sporules, sometimes larger capsules opening by two or three valves,

and containing only a few large granules. The capsules are sometimes axillar and solitary, sometimes aggregated in the axils of bracteæ, forming simple or digitate spikes.

205. *Mosses.*—The *Mosses* are small plants entirely composed of cellular tissue, but having a distinct axis of vegetation, or stem, covered with leaves. Their reproductive organs are of two kinds: axillar, cylindrical, or fusiform bodies, containing minute roundish particles; and *Thecæ* or capsules, supported upon a stalk or *Seta*, covered with a *Calyptra*, closed by an *Operculum*, within which is a *Peristome*, composed of slender processes,

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Description of Plate XVI. Seeds. Fig. 195. The same as Fig. 194, more advanced, and become a young plant, showing leaves and radicles. Fig. 196. Young plant of *Funaria hygrometrica*. Fig. 197. Powdery wart of a Lichen, presumed to be its barren flower. Fig. 198. Vertical section of the shield or fruit of a Lichen, showing the seeds imbedded in its disk. Fig. 199. Section of the seed of a Date, *Phœnix Dactylifera*, from Gœrtner, having a lateral cell in the albumen, in which the embryo is lodged. Fig. 200. Section of the Vitellus of Zamia, with its embryo. Fig. 201. Rough coats of the seeds in *Cynoglossum*. Fig. 202. Fruit of a Carex. Fig. 203. Seed of *Afzelia*, with its cup-shaped arillus. Fig. 204. Pappus or seed-down of a *Tragopogon*, being a calyx surmounting the pericarp. Fig. 205. Tail of the seed in *Dryas*. Fig. 206. Beaked fruit of *Scandix*, its two achenia separated from the base. Fig. 207. Winged seed of *Embothrium*. Fig. 208. Section of the conical, hollow receptacle of the Daisy. Fig. 209. Cellular receptacle of *Onopordum*. Fig. 210. Ligulate floret, having a stamen and pistil, in the Dandelion. Fig. 211. Ligulate floret, having a pistil, but no stamens, in the Daisy. Fig. 212. Tubular floret, from the disk of the Daisy. Fig. 213. Capsule of a Moss, with a double peristome or fringe, the operculum shown apart. Fig. 214. A portion of the same peristome magnified, and showing the teeth.

named *Teeth*, and having a central axis or *Columella*, the space between which and the walls of the theca is filled with minute *Sporules*. In Pl. XII., Fig. 150 represents a portion of moss with its theca and operculum ; Fig. 151, the calyptra. Pl. XVI., Fig. 213, shows the seta, theca, peristome, and operculum, of a moss ; Fig. 214, the teeth of the peristome. The other bodies spoken of above are represented by Pl. XV., Figs. 190, 191, 192, The reproductive sporule, Fig. 193, is seen in the process of germination in Fig. 194 ; and Pl. XVI., Fig. 195, shows the same farther advanced; while Fig. 196 shows another moss in the same state.

206. *Hepaticæ.*—The *Liverworts* or *Hepaticæ* are small plants, having a loosely cellular substance, and presenting the appearance of simple or lobed membranes, furnished with a midrib, or having a small branched stem bearing leaves. The reproductive organs are either oblong or globular bodies, containing a minutely granular substance, escaping by an aperture, or *Capsules* containing numerous sporules mixed with spiral filaments, covered at first with a *Calyptra*, at length rising on a peduncle, and opening into two or four valves. Pl. XII., Fig. 152, represents one of these globular capsules, with its calyptra.

207. *Lichenes.*—The *Lichens* vary in form and texture, but may be defined as composed of fronds or *Thalli*, presenting the appearance of membranous, powdery, leathery, or gelatinous crusts or expansions ; simple or variously lobed ; spreading on the ground, on rocks, stones, the bark of trees, and dead wood. The reproductive organs are of two kinds: *Soridia*, or heaps of pulverulent bodies scattered over the surface of the thallus, Pl. XVI., Fig. 197 ; or *Apothecia*, varying in form and colour, Fig. 198, and enclosing the sporules.

208. *Characeæ.*—These are aquatic plants, having

slender, branched, green stems, with verticillate leaves, on the upper of which are *Capsules*, each surrounded by two or three bracteæ, and containing numerous sporules. There are also on the branches sessile and rounded tubercles of a reddish colour.

209. *Algæ.*—These plants are aquatic, some growing in the sea, others in fresh water. They are destitute of leaves properly so called, and present various forms, being globular, filamentary, tubular, or laminar, simple or branched, continuous or articulated. Their organs of reproduction are minute *Sporules*, contained in *Sporidia*, variously grouped, and usually placed in the substance of the plants. All the plants named Sea-weeds belong to this family.

210. *Fungi.*—The *Fungi* are extremely diversified in form, consistence, and colour; being globular, oval, cup-shaped, elongated, filamentary, simple or branched, and composed of congeries of cellules. Their reproductive organs consist of *Sporules* lying loose in the cellular tissue, or enclosed in membranous cases or sporidia. Many of them have a form resembling that of an umbrella, being furnished with a *Pileus* or convex part, having on its lower part *Tubes* or *Laminæ*, and a central or lateral *Stipe*. Fig. 154, Pl. XII., represents a mushroom covered with its *Volva*. Fig. 153 shows the stipe and pileus of another, with the former having upon it an *Annulus*, being the remains of the volva. These plants, together with the Algæ, are considered as forming the lowest or least organized of the vegetable series.

211. *Structure of Acotyledons.*—It was stated, §§ 29, 30, that, on account of their peculiar mode of growth, the stems of Dicotyledonous trees are named Exogenous; those of Monocotyledonous trees, Endogenous. Another term, *Acrogenous*, has been applied to the stems of Ferns, which are cylindrical, usually hollow, or, if solid,

having the central part composed of a spongy substance, destitute of woody fasciculi or medullary rays, and having their external part composed of very hard plates folded upon themselves. These plates, on being once formed, continue without change as to number or quantity, and seem to be prolongations of the woody matter lying within the stalks of the leaves. Stems of this kind differ in structure from those of exogenous plants, which increase by addition to the outside of their wood, and from those of endogenous plants, which increase by addition of woody or vascular fibres to their interior. They seem to undergo little or no enlargement in diameter, and merely to elongate by the extension of their summit, whence the term Acrogenous, by which they are distinguished.

212. *Centrifugal Growth.*—Another mode of growth, termed *Centrifugal*, is that of fungi, lichens, and other acotyledonous plants, which consist either of a spongy mass, or of filaments radiating from a common centre. "In an obscure plant called Marchantia, Mirbel found, that a little thin green plate was first formed by the action of the reproductive granules; and that it was from the edges of this plate, when once fully formed, that all the succeeding expansions took place, as from a common centre, but always upon the same plane; so that in such plants the central part is the oldest, and the circumference the youngest. This is very apparent in lichens, which, when very large, are always dead in the centre, while they continue to go on growing from every part of their margin. Fairy rings are an exemplification of the same thing in fungi. These appearances are external indications of the centrifugal growth of the subterranean stems of certain Agarics, which originally spring from a common point, continually spreading outwards upon the same plane, the central or

first-formed parts perishing as the circumferential or latest-formed parts develope."

Recapitulation.

200. What are the families of Flowerless Plants? Explain the terms phanerogamic and cryptogamic. What are Spores? 201. Give a general account of Ferns. 202. Describe the Equisetaceæ. 203. What are the Marsileaceæ? 204. What plants do the Lycopodiaceæ resemble? Describe their organs of fructification. 205. What parts are observed in the theca or capsule of a Moss? 206. Describe the reproductive organs of the Hepaticæ. 207. Where do Lichens grow? What are their Soridia and Apothecia? 208. Describe briefly the Characeæ. 209. Of what nature are the reproductive organs of the Algæ. 210. What parts are observed in the Mushrooms properly so called? 211. Why are the stems of Ferns said to be Acrogenous? Give an account of their structure. 212. In what plants is the Centrifugal mode of growth observed?

SECTION II.

FUNCTIONS OF PLANTS.

CHAPTER XIX.

GERMINATION, GROWTH, AND MATURATION OF PLANTS.

213. GERMINATION.—Plants being destitute of sensibility and voluntary motion, have a less complex structure than animals, to which these faculties are essential. Fixed in a particular spot, they increase in size by imbibing the nutritious elements by which they are surrounded, are acted upon by the atmospherical agents, and having reached the term of their annual or final development, produce embryos of future individuals of their species. Their functions are thus confined to nutrition and reproduction, the most intelligible mode of observing which is to trace a plant from the commencement of its growth to the completion of its organization. Every plant originates from an impregnated ovule which has been converted into a ripe and perfect seed. The act by which a seed, on being placed in suitable circumstances, becomes developed so as to produce a plant similar to that from which it sprang, is named *Germination.*

214. *Conditions of Germination.*—The agents essential to this process are heat, moisture, and air. If a seed be put into a place, the temperature of which is below the freezing point, it remains torpid. On the other hand, if the heat be very high, the seed is quickly dried

up, or, if kept moist, is softened and deprived of its vitality. But if the temperature be moderate, and other circumstances favourable, it soon begins to germinate. Moisture is equally necessary, but must also be supplied in moderate quantity. It softens the covering of the seed, which is often very hard, rendering it more easy for the embryo to burst it; and it affords a vehicle to the substances which nourish the young plant. Atmospheric air is not less necessary; for seeds buried to such a depth as to be beyond its influence, remain in torpidity. But light, instead of accelerating the development of the embryo, seems to retard it, and seeds are found to germinate readily in darkness. The conditions required for germination, then, are access to moisture and air, and a moderate temperature. These conditions are frequently found to exist in the ordinary circumstances in which seeds are left after dropping from the plants which produced them, but are more surely obtained by the interference of man, whose ingenuity enables him to place them in the most favourable circumstances.

215. *Phenomena of Germination.*—1. The first evident effect of germination is the swelling of the seed, and the softening of its envelopes. The latter burst after a certain time, irregularly in some seeds, but regularly in others. The period which elapses between the time when seeds are placed in a situation favourable to their development, and the time of germination, varies from a few days to two years. Thus, the common Cress germinates in two days, the Turnip in three, the Lettuce in four, Grasses in a week, Hyssop in a month, many Pines in a year, and the Hazel and Holly not until two years. 2. The next effect is of a chemical nature, and is called *decarbonization.* In order to understand this process, it must be known that, during the *ripening* of the seed, a large quantity of carbon is fixed in its tissue, for the pur-

pose of insuring its durability. But this carbon will not readily dissolve in water, and must therefore be got rid of, in order to render the albumen and cotyledons available for nourishing the embryo. As an instance of this, it was found by Senebier that unripe peas germinate more rapidly than those which are ripe, the former containing more liquid water, and less carbon. Accordingly, in germination, the oxygen of the air unites with the carbon of the seed, producing carbonic acid, which is expelled; and the remaining substances are converted into saccharine matter, which supplies nutriment to the embryo. Hence it appears, that, during germination, a seed undergoes a process exactly the reverse of that which takes place during its maturation: in the one process, it *fixes* carbon; in the other, it *discharges* it.

216. *Illustration of the Phenomena of Germination.*—The process of *converting barley into malt*, by exposure to warmth, moisture, and air, affords an excellent means of studying the phenomena of germination. The barley is first steeped in water for about two days, during which it absorbs moisture, becomes soft, and swells considerably. It is then removed to a frame, where it is laid in heaps for about thirty hours; in this state its temperature is raised, and it is disposed to germinate. In order that the heat may be diffused equally through the mass, and that each grain may be brought into contact with the air, the barley is spread out on an airy floor, and frequently turned, for about fourteen days, until the germination has advanced to the extent required by the maltster. So soon as the matters contained in the grain have been converted by these processes into saccharine matter, it is necessary to arrest the germination; for, otherwise, the embryos would rapidly absorb the whole of the nutriment thus produced. The grain is, therefore, now removed to the kiln, where it is exposed to a tem-

perature gradually rising from 100° to 160°, for the purpose of drying the grain completely, and of providing against the continuance of germination by destroying the vitality of the embryos. Hence it appears that, during the germination of the barley, its hordein, which is insoluble, and cannot be applied to the uses of the young plant, is converted into starch, gum, and sugar, the last two of these principles being soluble, highly nutritive, and capable of being absorbed by the embryo.

217. *Germination in Dicotyledons.*—In the dicotyledonous seed, the radicle is generally conical and protruded, the caulicle cylindrical, and the gemmule placed between the bases of the two cotyledons, which are applied to each other. The entire mass of the seed becomes permeated by moisture and swells. The perisperm or testa bursts; the radicle elongates, and gives out delicate ramifications; the gemmule rises and emerges from between the cotyledons; the caulicle elongates and raises the cotyledons, which separate, expand, become green, and are converted into leaves. When albumen is present in the seed, it softens, and gradually disappears, being absorbed by the embryo.

218. *Germination in Monocotyledons.*—The embryos of monocotyledonous plants have a greater uniformity of structure, so that their parts are often not easily distinguished until germination has commenced. The radicular extremity elongates, bursts through its sheath or coleorhiza, and passes downwards. Several radicles generally come off from the lower part of the caulicle, and when these are well developed, the principal radicle disappears, so that plants of this kind never have a tapering root, like that of the dicotyledons. The cotyledon enlarges, and is perforated by the gemmule, which emerges from its side or base, enclosed in a sheath, called the *coleoptile.* It then perforates this sheath, and elongates.

219. *Progress of Dicotyledons.*—In this state the young plant consists chiefly of cellular tissue, but with vascular fibres forming a kind of cylinder in the centre. This cylinder is the medullary sheath; within it is the pith, and externally the bark. The root imbibes liquid, which passing upwards through the cellular tissue, enters the cotyledons, where it is aerated, and in part passes down through the bark into the root. The plumule gradually ascends, its rudimentary leaves are developed, and soon acquire their full size, when they aerate the sap or mass of imbibed fluid, give out oxygen, and retain carbon. The axis of the plant elongates, other leaves are developed upon it, and a layer of fibres is formed between the pith and the bark. At length, as the season draws to an end, the development of the plant is arrested, and the leaves fall off, while in the axilla of each is formed a bud, composed of a rudimentary branch and leaves. If now examined, the stem will be found composed of a central axis of dry cellular tissue forming the pith, a cylinder of woody tissue, and an outer cylinder of bark.

220. *Continued Progress of Dicotyledons.*—During the winter the plant remains in a torpid state, but on the return of warm weather vegetation recommences. The sap ascends through the wood of the previous year, the buds gradually expand into branches covered with leaves, by which the fluids are aerated. Each new branch exhibits the same phenomena as the stem of the first year, on which a glutinous fluid, called *cambium*, is found interposed between the wood and the bark, in the place of which are ultimately formed a new layer of wood, and another of bark. The leaves fall as before, leaving buds in their axillæ. After a period of repose, vegetation is resumed in spring, continued through the summer, and produces the same results. Each successive year, a new layer of wood and a thinner layer of bark are added.

When the tree has attained the age of puberty, which varies in different species, and in different individuals of the same species, flower-buds are formed, which unfold their parts. The anthers burst, and part of their pollen adheres to the humid stigma. The grains of pollen emit a delicate tube, which, penetrating the stigma and style, transmit the fecundating influence to the ovarium. The ovula being impregnated, the petals and stamens fade, the ovarium enlarges, and the seeds are perfected. At the end of the season, they fall to the ground, either contained in the pericarp, or after escaping from it, according to the species.

221. *Progress of Monocotyledons.*—It has been seen that the enlargement of the stems of dicotyledonous plants takes place by the addition of new matter between the wood and the bark, or near the circumference; whence the plants are named Endogenous, that is, growing at their exterior. But in monocotyledonous plants, the growth is in the inside; whence they are named Endogenous. When a monocotyledonous plant has germinated, and the plumule has shot up, a leaf is emitted from its base. This leaf is succeeded by another, arising from its axilla, and facing it; a third, a fourth, and others follow in succession, until the stem is ready to be produced. The bases of the leaves being upon the same plane, each having been produced from the axilla of the other, without any intervening space, a kind of fleshy stock is produced by their union, consisting of parenchymatous tissue, with perpendicular fasciculi of vascular and woody tissue, continuous with the veins of the leaves. The whole body is thus a mass of cellular, vascular, and woody tissue, intermingled, without any distinction of pith, medullary sheath, or bark. This mass now elongates upwards; leaves are developed from its central part or apex; the former leaves are left forming a circle at

the base; and when the stem has ascended to some height, a new circle, or a spiral series, is formed. The new leaves thrust toward the circumference those which preceded them; the old leaves decay, their bases remaining as part of the stem ; which does not increase in diameter, and has its central parts of softer texture than those toward the exterior, the pressure acting from within, so that the outer parts ultimately assume the appearance of a solid mass of woody fibres, the cellular tissue having become almost obliterated. In this manner, the growth of palms, and many arborescent monocotyledonous plants, takes place. Other plants of that series exhibit differences in their mode of development; the Grasses, for example; but in all, the stem differs from that of dicotyledonous plants.

222. *Growth of Flowerless Plants.*—The sporules of these plants appear to germinate from any part of their surface, there being in them no distinction into radicle and plumule. In some, however, roots and stems are formed much in the same manner as in monocotyledonous plants. In Tree Ferns the stem appears to be produced by the bases of the leaves. In the purely cellular tribes, the parts seem to be mere expansions of the cellular tissue; but on this subject nothing very precise can be stated.

223. *Growth of Plants in General.*—By the absorption of fluids by the roots, a mass of nutritious matter is gradually accumulated in the stem and branches. This fluid passing into the leaves, there undergoes a process by which part of the water is discharged, the remaining part being subjected to the action of the atmosphere; carbonic acid is generated, and then decomposed by the action of light; carbon is fixed in the form of a nutritive material, which is carried into the system ; a further elaboration of this material takes place, after which it is

applied to the development of all the organs; while, by certain changes, it is also converted into various matters, which are either retained or ejected. The stems and branches, with the leaves and stipules, are gradually developed; the flowers make their appearance, and unfold their parts; the anthers shed their pollen, the application of which to the stigma is followed by the development of the ovules; the fruit is at length matured, and drops to the ground, where the seeds, under favourable circumstances, become developed into new individuals. The various processes by which the results of vegetation are obtained, may all be resolved into the two functions of Nutrition and Reproduction. But before treating of these, it is necessary to advert to circumstances having reference to the vital power of plants, the properties of vegetable tissues, and the agents by which vegetation is stimulated.

RECAPITULATION.

213. What are the principal functions of plants? From what do plants originate? What is meant by Germination? 214. What agents are essential to germination? Do seeds germinate at a temperature below that of freezing? What follows when the temperature is too high? What are the uses of moisture in germination? Is light beneficial? Is air necessary? 215. Within what periods does germination take place in different seeds? Explain the process of decarbonization. 216. Illustrate the phenomena of germination, as they occur in the process of malting barley. 217. Describe the germination of Dicotyledonous Plants. 218. How does germination take place in Monocotyledonous Plants? 219, 220. Give an account of the progress of growth in Dicotyledons. 221. Describe the progress in Monocotyledons. 222. How are Flowerless Plants developed? 223. Give a short account of the growth of Plants in general.

CHAPTER XX.

VEGETABLE LIFE, PROPERTIES OF ORGANS, AND STIMULANTS TO VEGETATION.

224. *Vegetable Life.*—Plants exhibit phenomena similar to those which in animals are considered as characteristic of vital agency, agreeing with them in many essential respects, although they differ in others, especially in being destitute of sensibility and voluntary motion. What life really is, whether it be a principle, or influence, or substance, apart from the material fabric by which its phenomena are exhibited, or merely the result of the operation of the elements of nature upon organs adapted for the purpose, seems to be little known. We may therefore speak of life, either as a distinct principle, or as the general result of the operations of an organized body. In reference to this subject, little more can be said of plants than that they are organized and living bodies, having a less complex structure, and exhibiting less remarkable vital actions than animals, between which and mineral bodies they are intermediate, although more intimately allied to the former than to the latter.

225. *Properties of Vegetable Tissue.*—The cellular and vascular tissues of plants possess various properties in common with animal tissues. Thus, they are extensile, elastic, and absorbent. But they are destitute of the irritability manifested by muscular fibre, and of the sensibility dependent upon nervous influence. The processes of secretion and circulation are performed in a different manner in plants and animals. From the manner in which the elementary organs are intermixed in plants,

and the impossibility of tracing their actions separately, or in succession, our knowledge of their functions is very imperfect. 1. The *Cellular Tissue* has the property of transmitting fluids in all directions. In many plants there is no other kind of tissue, and yet the sap circulates in all their parts. The pith, the medullary rays, the parenchyma of the leaves, and the greater part of the bark, are composed of it; and in all these parts, at some period, the fluids are diffused and propelled. 2. The *Woody Tissue* is also pervious to fluids, and gives firmness and elasticity to the parts in which it occurs. Wherever vascular tissue exists, it is protected by bundles of woody tissue; and, hence, many parts in which they are united, as the veins and petioles of leaves, are described as composed of fibro-vascular tissue. 3. The *Vascular Tissue* is partly subservient to the transmission of fluids, and partly of air; at least, the spiral vessels are generally believed to contain the latter. The elasticity of tissue is obviously displayed in many instances, and is more conspicuous when the parts are distended with fluid. The effect of moisture, producing what is called Hygroscopicity, gives rise to motions, which might often be supposed to depend upon irritability.

226. *Irritability.*—The irritability of plants, if not different from that of animals, is, at least, of a much inferior character; and has therefore been by some referred to a property, to which is given the name of Excitability. This property is defined as being that by which the tissue becomes in some manner or degree sensible of the action of external influences, and by which it resists such as would otherwise decompose it. It is a property of life, it is said, to resist destruction, and this property is possessed by plants in common with animals. The irritability of animal organs, being inherent in muscular fibre, can have no place in plants; and what is meant by

the term in Vegetable Physiology is merely the result of movements, which may be referred to other causes. The closing of the leaves and flowers of plants, the shrinking of others when touched, the motions of the leaves of *Dionœa*, and of the stamens of the Barberry, are of this kind.

227. *Sleep of Plants.*—Toward the approach of night, in plants which have compound leaves, the leaflets fold together, and the petiole is bent downwards. At the return of day the petiole rises, and the leaflets expand. In some plants, the leaves converge over the flowers; in many, the flowers themselves close, in the absence of the direct light of the sun. The corollas of the Dandelion, Daisy, and many other *Compositœ,* become erect in gloomy weather, and spread out in sunshine. The Lupine drops its leaflets at dusk. The *Convolvulus minor* closes its corolla early in the evening, and opens it again as soon as the sun is above the horizon. The *Lotus ornithopodioides* hides its blossoms beneath its leaves in the evening, so as to escape detection altogether by the most inquiring eye. Phenomena of this nature have been termed the Sleep of plants, and are, no doubt, in some way owing to the action of light, although other causes may also operate.

228. *Movements caused by Touch.*—The Sensitive Plant, *Mimosa pudica,* has long been known for the property possessed by it, in common with other species, of folding up its leaves when touched, or burnt, or otherwise injured. The leaves of this plant are compound, with four pinnate divisions, each partial petiole being furnished with numerous pairs of leaflets. If one of the leaflets be touched, it rises along with its fellow, the leaflets successively bring their upper surfaces together in pairs, and incline toward the summit of the partial petiole; the other *pinnœ* go through the same action, the four par-

tial petioles come together, and lastly, the petiole itself bends downwards. It appears that the elevation and depression of the leaf is somehow produced by the tissue in the tumid basal part of the petiole, for, if its upper portion be cut off, the petiole remains erect, but if its lower portion, it remains depressed. Dutrochet considers that the transmission of the excitation is effected by the woody part of the plant, and not by the cortical or medullary parts; for these, he found, might be entirely removed, and irritation above or below the spot would still be propagated beyond it. The excitation extends gradually from the points to which the stimulus is applied; first, the nearest leaves, then the most distant, becoming folded. The excitability is greatly influenced by light and temperature, as well as by the pressure or absence of atmospheric air. Both the excitability and the mobility of the *Mimosa* are lost after a few days, when the plant is deprived of light; the susceptibility of external stimulus being lost before the movements of sleep and waking cease. Variations in the temperature of the atmosphere also cause the quickness of the transmission of the excitation from one part of the plant to others to vary; and at 47¾° Fah. no motions could be excited.

229. *Spontaneous Movements.*—Some plants exhibit motions which have been called Spontaneous, merely because not excited by touch or external violence. Of this kind are those of the two lateral leaflets of the ternate leaves of *Hedysarum gyrans*, which are in continual motion, day and night, especially in warm weather. When the fruit of *Momordica elaterium* has attained maturity, its peduncle is suddenly expelled, along with the seeds, and the mucilaginous fluid by which they are surrounded. But, according to Dutrochet, this phenomenon is caused by a circumstance of general occurrence in plants, to which he has given the name of Endosmose.

230. *Endosmose.*—Although vegetable and animal membranes, when examined with the microscope, are not observed to have any pores, but appear perfectly continuous, it is found that liquids readily pass through them. If mucilage, or gum dissolved in water, be enclosed in a piece of bladder, which is then immersed in water, a portion of the gum will pass through the bladder into the water, of which a portion will, on the other hand, pass into the bladder. If the experiment be reversed, so will the result. It is the same with milk, or any other liquid. The general law, according to M. Dutrochet, is, that when two fluids of unequal density are separated by a membrane, the denser fluid will attract the less dense. When the attraction is from without inwards, he names the action *Endosmose;* when from within outwards, *Exosmose.* The transmission he considers as caused by galvanic agency. There can be no doubt that many of the phenomena of vegetation are dependent upon this property of membrane; and some are of opinion, that it is the principal cause of the motion of the fluids of plants.

231. *Action of Poisons.*—As a proof of the existence of sensibility in plants, has been adduced the action of many substances, which prove destructive to life, without corroding or decomposing the tissue. M. Marcet, of Geneva, found, that not only oxide of arsenic, corrosive sublimate, preparations of lead, tin, and copper, potash, and other acrid poisons, on being absorbed by the roots, produce death; but also solutions of opium, nux vomica, belladonna, prussic acid, and other narcotic poisons, which are understood to act upon the nervous system in animals. From the experiments made, he infers, that metallic poisons act on plants nearly as on animals, altering and destroying the tissue by their corrosive powers; and that vegetable poisons, especially those which cause death in animals by their action upon the nervous sys-

tem, destroy life in plants without altering the tissue. Similar results have been obtained by M. Macaire, and others. Yet nothing analogous to a nervous system, even of the kind observed in the lower series of animals, has been observed in plants.

232. *Stimulants of Vegetation.*—Whatever may be the kind or degree of sensibility possessed by plants, or whatever the peculiarities of the intimate structure of their organs, we know that their vital power languishes or remains dormant, or, on the other hand, manifests itself with greater energy, according to the varied influence of external agents. Thus, a seed will not germinate unless supplied with moisture and atmospheric air, and submitted to a moderate temperature; after a long drought, plants become shrivelled and languid; and, when deluged with continued rains, shoot out long but feeble stems, or, if they perfect the branches and leaves, bear little fruit. The stimulants to vegetation are light, heat, electricity, air, and water.

233. *Action of Light.*—When a plant is made to vegetate in a cellar or other dark place, it remains white; and when brought into the light, soon acquires its natural green colour. The practice of blanching Celery and Kale, by covering them from the light, is familiar to every one. Light being essential to the healthy development of all the parts of plants, not only the stems, but the leaves and flowers, manifest a tendency to direct themselves toward it. In the open air, the upper surface of leaves is turned toward the sky, and in a hothouse all the plants present the fronts of their leaves. Many flowers are equally sensible to light, and especially those of the *Compositæ*, such as the Dandelion, Daisy, and Sunflower, which are observed in some degree to turn themselves toward the sun. What is called the Sleep of Plants, § 227, or the folding up and drooping of their

leaves at night, appears to depend chiefly upon the diminution of light; for it has been found, that some plants will unfold their leaves under the action of lamp-light. The colours of the flowers, the odorous secretions of plants, and the firmness of their texture, also depend, in a great measure, upon the supply of light.

234. *Action of Heat.*—The great influence which temperature exercises on the development and functions of plants, is abundantly obvious. When other circumstances are equal, the vegetation is much more vigorous in warm than in cold climates. In countries where the temperature is below the freezing point, plants cannot exist; and during winter, when the same takes place, no nourishment can be obtained by the roots, as the water in the soil is frozen. It does not appear that any natural degree of heat is injurious to vegetation, provided moisture be supplied in sufficient abundance. But all plants are not equally adapted for bearing the same degrees of heat or cold. Some grow within the influence of hot springs, in which the thermometer stands at 200°; while others are capable of resisting the severity of winter in climates where the temperature falls to 30° or more. Most tropical plants are killed by a freezing degree of cold; and many introduced into our climates require an artificial temperature. On the other hand, many of the plants of cold climates do not thrive in tropical regions. Particular species thus have a peculiar constitution; and it has been found, that some have a higher temperature than others. It is a general law in our climates, that the temperature of trees is higher in winter than the average temperature of the air, and lower in summer; which may be accounted for, in a great measure, by their roots penetrating to a depth where the soil is always warmer than the air in winter, and colder in summer. It has been observed that some plants, at

the period of flowering, emit a considerable degree of heat. This has been observed, particularly in the Arums, Senebier having noticed that the temperature of the spadix of *Arum maculatum* was 7° higher than that of the surrounding air; and M. Hubert, on placing a thermometer in the centre of twelve spadices of *Arum cordifolium*, in the Isle of France, having found the temperature to be 121°, while that of the air was only 66°.

235. *Action of Electricity.*—It has been observed, that plants grow with increased vigour during electrical weather; but in this case, the high temperature, and abundant supply of moisture, which accompany thunder-storms, may of themselves account for the phenomenon. It has long been an opinion, that some trees are more liable to be struck by lightning than others; and this is probable enough, although it does not appear that the subject has undergone any strict examination. All trees, however, by the numerous points which their twigs and leaves present, are well adapted for silently drawing electricity from the clouds.

236. *Action of Air and Water.*—Plants, like animals, when deprived of air, perish. It is by the action of this fluid upon their elementary organs and juices, that materials are procured for the development of their parts, as will be subsequently explained. Atmospherical currents, by agitating the stems and foliage, promote the circulation of the sap; but when their velocity is great, they frequently prove injurious, by breaking or bruising the organs. Water, being the vehicle of all the nutritious matters absorbed by plants, is essential to their existence. When it is supplied in diminished quantity, they become stunted; and when furnished in too great profusion, they acquire an inordinate development, but are unable to discharge all their functions in an efficient

manner. Continued or heavy rains are injurious to the impregnation of the ovules, by washing away the pollen before it has exerted its influence. But, as in the subsequent chapters, these and other circumstances will be explained, it is inexpedient to offer any further observations on the action of water.

We now proceed to the consideration of the functions of Nutrition and Reproduction.

Recapitulation.

224. Have plants many properties in common with animals? 225. What are the properties of the tissues of plants? Do fluids circulate in the cellular tissue? What properties have the woody and the vascular tissues? 226. Are plants possessed of Irritability? Does it differ from that of animals? What is Excitability? 227. What is meant by the sleep of plants? Illustrate this phenomenon in several plants. 228. What plant exhibits peculiar motions on being touched? 229. Have plants spontaneous motions? 230. What are the phenomena designated by the terms Endosmose and Exosmose? Is it probable that they operate in plants? 231. Are plants acted upon by poisons, in the same manner as animals? As vegetable poisons act upon the nervous system in animals, is it proved, by the similarity of their action in plants, that the latter have a nervous system? Have nerves been detected in plants? 232. Mention the principal stimulants to vegetation. 233. Give some account of the action of Light upon plants. 234. What effect has Electricity upon them? 235. State some particulars relative to the influence of Heat. What plants have been observed to emit heat? 236. What effects are produced on plants by the action of air and water?

CHAPTER XXI.

FUNCTION OF NUTRITION.

ABSORPTION. THE ASCENDING SAP, OR LYMPH. PROGRESSION OF THE LYMPH. EXHALATION. RESPIRATION.

237. *Function of Nutrition.*—We have seen that plants are furnished with roots, stems, leaves, flowers, and fruits, together with various subordinate parts; and it has been stated, § 6, that these organs may be physiologically disposed into two classes; the root, stem, and leaves being subservient to the function of *Nutrition*, the flower and fruit to that of *Reproduction.*

When the young plant is developed in consequence of germination, it extracts from the soil or the air the materials necessary for its further growth, and assimilates them, or transforms them into its own substance. This great function, which characterizes the second epoch in the life of the plant, is known by the name of NUTRITION. It includes several subordinate functions, which establish as many distinct periods. The plant extracts its food from the ground by means of its roots; the nutritious fluid or sap is then conveyed through the stem to the leaves; there the superfluous water is expelled; the remaining part is in the same organs submitted to the action of the air, part of which combines with it; the sap thus altered, descends from the leaves to the roots, and is applied to the nourishment of all the organs of the plant; lastly, the portion of the sap not required for this purpose is converted into substances, intended for particular uses, or to be ejected from the

plant. These subordinate functions or processes may be designated:—

1. *Absorption*, or imbibition of liquid.
2. *Progression*, or ascent of the crude sap.
3. *Exhalation*, or transpiration of liquid.
4. *Respiration* of oxygen—of carbonic acid.
5. *Retrogression*, or descent of the elaborated sap.
6. *Increase*, or growth of the plant.
7. *Secretion* of retained or rejected matters.

238. *Absorption.*—It was stated, § 32, that the Roots, besides fixing the plant in a commodious situation, extract from the soil, by the spongy extremities of their fibrils or radicles, the substances intended for the nourishment of the plant. The nutritious particles must be dissolved or suspended in water before they can be absorbed. Now, all vegetable tissues have the property of attracting water until they are in equilibrium as to humidity with the surrounding bodies. This action of vegetables is known by the name of *Absorption*, or Suction. The leaves absorb moisture from the atmosphere, chiefly by their lower surface, and all the green parts of plants possess the same faculty; but it is chiefly by the roots that this function is performed. These organs are especially adapted for the purpose, by having the extremities of their fibrils destitute of cuticle; and, as the ground is never entirely deprived of moisture, and is often profusely supplied with it, a constant fund of nutritious matter is afforded. Some plants, however, vegetate luxuriantly in an arid soil, and are furnished with very small roots. They must, therefore, extract their nourishment almost exclusively from the atmosphere, which they absorb by their whole surface. This is what is specially observed in succulent plants, or those having thick and fleshy leaves and stems; as Cactus, Houseleek, and Stonecrop.

239. *Food of Plants.*—The food of plants consists of carbon, hydrogen, oxygen, nitrogen, and certain earthy particles or ashes.

(1.) The *carbon* of plants is mainly derived from carbonic acid, taken either from that of the air, or from that which is evolved by the spontaneous decomposition of manure in contact with the roots. But it is from the former source especially that plants derive their carbon, —a statement which cannot be doubted, when we reflect upon the enormous quantity of carbon which has been fixed by trees of long growth, compared with the very limited extent of their roots. The soil into which the acorn fell, a hundred years ago, did not contain a millionth part of the carbon now deposited in the oak: the atmosphere has furnished all the rest. It was found by M. Boussingault, that peas sown in sand, watered with distilled water, and fed by the air alone, derived from this air all the carbon necessary for their development, flowering, and fructification; and that the leaves of a vine, enclosed in a glass vessel, absorbed the whole of the carbonic acid from a stream of air transmitted through the vessel, however rapid the transmission.

(2.) The *hydrogen* of plants is obtained by the decomposition of water, as carbon is obtained by the decomposition of carbonic acid. This follows from the experiment of the vegetation of peas in close vessels. The fact is proclaimed more decisively by the production of the fat and volatile oils which abound in various parts of plants, and are known to be rich in hydrogen. This can be derived only from water, inasmuch as plants have no other hydrogenous compound to feed on but water.

(3.) The *nitrogen* of plants is procured from the atmosphere, or from manures added to the soil. In either case it seems probable that the nitrogen enters the plant only in the form of ammonia or of nitric acid. The experi-

ments of M. Boussingault have shown that certain plants, as Jerusalem artichoke, abstract large quantities of nitrogen from the air ; and that others, on the contrary, as wheat, depend upon manure for the supply of this element of nutrition. "What an important distinction," says M. Boussingault, "is this for agriculture. Is it not obvious that we must begin by raising plants which assimilate the nitrogen of the atmosphere, with these feed animals which shall furnish us with manure, and then apply this to the culture of those plants which are dependent on manure for their nitrogen?"

(4.) The *ashes* found in plants are obtained through the medium of water, an immense quantity of which passes through a plant during the term of its existence. This water evaporates from the surface of the leaves, and necessarily deposits, as its residue, the salts which it held in solution. These salts constitute the ashes of plants—products evidently derived from the soil, and restored to it again by plants after their death. The forms in which these mineral products are deposited in the tissues of plants are numerous ; one of the most frequent and abundant forms is that of pectinate lime, which occurs in the woody tissues of most plants. Other matters are the phosphate of magnesia, common salt, nitre, the salts of iron and copper, &c.

240. *Causes and Stimulants of Absorption.*—The juices existing in the plant at germination, and in the earliest stage of its subsequent development, being probably denser than the surrounding liquid or aerial media, the absorption of these media may perhaps be accounted for by endosmosis. If the tissue had the power of removing the fluids, and causing them to ascend as fast as they are absorbed by the spongioles, we might, as Professor Henslow remarks, imagine the possibility of a supply being kept up by the mere hygroscopic property of the

tissue, much in the same way as the capillary action of the wick of a candle maintains a constant supply of wax to the flame by which it is consumed. The action of the spongioles is indirectly stimulated by the atmospheric heat and light which cause the removal of a large portion of the general mass of fluid by exhalation; but light is not a direct stimulant, for plants absorb in the dark, and the roots are generally deeply buried in the soil. It does not appear that many substances, which stimulate the organs of animals, have any such effect upon the radicles of plants, which as readily absorb inert as acrid, and noxious as useful, matters, provided they be sufficiently comminuted or dissolved. It might appear, from the effects of manure, that it must stimulate the roots, otherwise it might seem impossible to account for the rapid growth to which it gives rise.

241. *The Lymph.*—The mass of fluid imbibed by the root and other absorbent surfaces is named the *Ascending Sap* or *Lymph.* In its most simple state, it is found to be composed of water, with a little mucilage or sugar. As the two latter substances do not exist in the soil, it must be inferred that they have been produced within the plant by some chemical action upon the imbibed liquid. Of the many other substances found in plants, although in very small quantity, as flint, some suppose them to be products of the vital action of the plant itself, while others, with more probability, maintain that they must have been absorbed from the soil. In the first state of the sap, the substances which it holds in solution or suspension bear an extremely small proportion to the mass of water.

242. *Progression of the Sap.* — The aqueous fluid absorbed by the root, and which is more abundant than that imbibed by the other organs, has a constant tendency to ascend towards the leaves. Hales removed

the soil from the root of a pear-tree and cut the root across; he then introduced the portion of the root attached to the tree into a tube filled with water, hermetically closed above, and dipping below into a basin of mercury; the water in the tube was absorbed by the section of the root, and this with such force that the mercury rose eight inches in the tube, to replace the water. In the stems of dicotyledonous trees, it has been ascertained that the course of the sap is through the woody tissue, and especially the alburnum or outer layers of softer wood. Its ascent takes place, as above stated, with great force; but there are circumstances in which its progress is accelerated, and its quantity increased, in a very perceptible degree. In general, heat increases its velocity, while cold diminishes it. In perennial plants, the sap is observed to be greatly increased at the commencement of spring, before the leaves have been developed. At this period, trees and shrubs absorb a great quantity of water, which mingles with the nutritious fluid with which all the parts are then gorged. Another period at which the sap accumulates is in August. It is to be remarked that the spring sap corresponds to the period at which the buds of the preceding year begin to unfold, and the August sap to that at which the buds of the ensuing year begin to be formed; as if these buds, whose development is due to the afflux of sap, attracted that nutritious fluid to them, and thus accelerated its ascent. If a tree be felled in spring, the sap is found to issue most abundantly from the central parts; but it usually or often pervades all the woody parts, and may be obtained in great quantity, in certain trees, as the Birch and Sycamore, by making an incision into the outer layers of the wood. It has not been ascertained whether the sap in its progress undergoes any alteration, analogous to digestion in animals; but

when a tree is tapped at different heights in spring, the fluid that exudes from the lower orifice is found to be clearer than that from the upper. This, however, may be owing to the admixture of the newly-absorbed liquid with the juices previously elaborated, and deposited in the wood. When it has arrived at the extremities of the branches, it enters the leaves, where it undergoes a change which renders it fit for becoming assimilated.

243. *Channels of the Ascending Sap.*—There is considerable difference of opinion respecting the channels through which the sap is conveyed. Some observers suppose it to be propelled through the ducts or vessels, others through the intercellular or intervascular passages, while others think it passes from cell to cell by transfusion. The cause of this discrepancy is the extreme attenuation of the vesicles and tubes of the tissue of plants, and the difficulty of being convinced whether the fluids are without or within the vessels, the microscope not affording a sufficiently distinct view of the parts. Whether by the intercellular passages or by transfusion from one cell or vessel to another, the sap, in its ascent, tends to a lateral extension, as is indicated by its reaching the summit of a tree in which deep incisions have been made at intervals on different sides. It appears, from the experiments of Mr. Rainey, that "the crude sap ascends along a tissue which chiefly exists *between* the cells, but which enters also into the structure of the more solid and permanent parts of a plant." The locality of this intercellular tissue may be seen by referring to Fig. 3, p. 9; in which the dark parts between the cells at *a* and *h* represent this tissue. "The quantity of intercellular tissue contained in different parts of the same plant varies very considerably; there is scarcely any between the cells of the pith, or between those containing the starch in cotyledons, but it exists abun-

dantly between all the cells of the wood, and also between some of the cells of the bark. The intercellular tissue, besides serving for the *ascent* of the sap, will, from its universal existence and general contiguity, be the means also of its *lateral* diffusion. The medullary rays are composed of cells longest generally in their horizontal diameter, and, like the cells of wood in other parts, surrounded by intercellular tissues." — (*Experimental Inquiry.*)

244. *Causes of Progression.*—The rapidity with which the sap ascends is evident from the great loss which plants often undergo from exhalation, and which must be made up by radicular absorption. A young leaf of a vine perspires so profusely in a hot day, that a glass placed near its lower surface is presently covered with vapour, which soon trickles down in streams. Hales found a sun-flower to lose one pound four ounces, and a cabbage one pound three ounces, a-day, by perspiration. This exhalation itself may be one cause of the ascent of the sap, although it may also be propelled by a power residing in the extremities of the roots. De Candolle supposes it to be conveyed along the intercellular passages by an alternate contraction and dilatation of the cells themselves; but of this it appears there is no proof. Hales, having cut off the stem of a vine in spring, and luted a bent tube to the top of the stump, found, by introducing mercury at the open end, that the force of the rising sap equalled the pressure of an atmosphere and a half. If a piece of bladder be tied over the surface of such a stump, it soon becomes distended, and ultimately bursts. These phenomena certainly indicate a powerful force, for which endosmosis and capillary attraction seem hardly sufficient to account. Du Petit Thouars, however, explains it on that principle. In spring, he says, when vegetation commences, the extremities of the branches

and the buds begin to swell; for the supply of these buds a quantity of sap is attracted from the neighbouring tissue, which is again instantly filled from that beneath it; and thus the whole mass of fluid is set in motion. He thus thinks that the expansion of the buds and leaves is not the *effect*, but the *cause*, of the ascent of the sap.

245. *Exhalation or Transpiration of Liquid.* — The sap, on arriving in the leaves, undergoes a change, of which the first stage is a diminution of its mass by the exhalation of a great part of the water which served as the vehicle of the nutritious substances contained in it. This is evident from the mere observation of fading plants, and from the deposition of moisture on the inner surface of a bell-glass, containing plants, and exposed to the sun; so much as two spoonfuls of water has been collected from the exhalation of a leafy branch in the period of two hours. The quantity of moisture exhaled has been measured by weighing the plant at different periods, and reckoning the amount of water supplied to it. In this way, Hales found that a sunflower lost 20 ounces, and a cabbage 19 ounces of water in the course of the day. He considered that, surface for surface, the plant exhales 17 times more than man. When the transpiration is moderate, the water, on arriving at the surface of the leaf, is entirely evaporated, and the process resembles that of insensible perspiration in animals; but when too large a quantity of fluid arrives at the surface, its evaporation cannot take place at once, and we then see it oozing in the form of extremely small drops at the tip of the leaf, and especially at the extremities of the nerves; several of these limpid drops often unite, and then acquire a considerable size. In this manner a large quantity of clear water is often seen collected on the leaves of the cabbage, poppy, and other plants. This

water is not produced by dew, as it forms when all communication of the plant with the ambient air is intercepted by covering it with a glass, and with the surface of the ground by applying over the latter a leaden plate having a hole in the middle for the passage of the stem. It having been found that those plants exhale most which have the greatest number of stomata, and that those surfaces which are destitute of stomata produce little effect beyond what may be accounted for by ordinary evaporation, it appears evident that the stomata are the exhalant organs, and exhalation is more abundant on the under surfaces of leaves, because there the stomata are generally most numerous.

246. *Stimulants to Exhalation.*—If we distinguish between ordinary evaporation, which operates alike on dead and living plants, and exhalation by the stomata, we find ourselves unable to account satisfactorily for the latter, as the manner in which the stomata act is unknown. When a plant is placed in a dark room, its exhalation ceases, and when restored to the light, returns. Hence it is inferred that light is its principal stimulant. Heat also appears to affect it; at least evaporation is thereby greatly increased. Many succulent plants have so few stomata, that they may be preserved for weeks out of the ground, without dying; on the other hand, submersed plants, which are destitute of epidermis, dry up rapidly on being exposed to the air. The water exhaled by the leaves is so pure that scarcely any traces of foreign matter are found in it. It is calculated that in general about two-thirds of the fluid absorbed by the roots are exhaled. The remaining portion, thickened and retaining the various substances originally dissolved in it, undergoes a further change.

247. *Respiration.*—By this term is denoted the function by which the atmospheric air and the fluids con-

tained in the vegetable organs mutually modify each other. 1. *During the day,* the slight portion of *carbonic acid* contained in the atmosphere is decomposed by the green parts of plants; the carbon is fixed within the plant, the oxygen remains in the air. Carbonic acid exists also in the liquid absorbed by the root; this quantity is also decomposed by the green parts, the carbon being, as in the other case, fixed in the plant, while the oxygen is restored to the air. This is sometimes termed the function of *digestion,* or the assimilating power of plants. 2. *During the night* plants absorb or inspire, by their green parts, a certain quantity of *oxygen* from the atmosphere; this gas appears to combine with the carbon contained in the sap, forming carbonic acid, which is afterwards decomposed by the action of solar light. Plants also, at all times, especially during the night, part with carbonic acid in small quantities. This absorption of oxygen and evolution of carbonic acid constitute the function of *respiration,* properly so called. 3. The healthful relation of plants to the atmosphere appears, therefore, to consist in the alternate decomposition and recomposition of carbonic acid; and its result is the increase of bulk in the plant, by the assimilation or *digestion* of carbon. 4. It follows also that plants are the great *purifiers of the atmosphere,* since they consume the products of animal respiration and of all organic putrefaction, and convert them into matter adapted to the use of man. It has been found that plants purify the air much more by their assimilating, than they vitiate it by their respiratory, function.

248. *Colour of Plants.*—The green colour of plants appears to result from the decomposition of carbonic acid, and the fixation of carbon; and as this effect takes place only through the action of light, we see how great an influence that agent exercises upon the coloration and

nutrition of plants. As already mentioned, vegetables which grow in darkness, are blanched, slender, and more watery and elongated than they would be, were they exposed to the sun's light. The green colour of plants, and indeed all colours, depend upon the presence of minute granules in the vesicles of the cellular tissue. The granules that produce the green tints are named *Chromule,* and are composed chiefly or entirely of carbon. The parts of plants which are coloured otherwise than green, do not assimilate the oxygen of the air, but whether by day or by night, this oxygen combines with a part of their carbon which is superabundant, and thus reproduces carbonic acid.

249. *Effect of Respiration on the Atmosphere.*—Plants *vitiate the air* around them, because their green parts inspire by night a certain quantity of oxygen, which they do not entirely restore by day, and because the parts which are not green form carbonic acid at the expense of their proper substance. On the other hand, plants *purify the air* by decomposing the carbonic acid formed within them, and that which they absorb dissolved in air or water. The ultimate effect of vegetation plainly consisting in an increase of the mass of carbon fixed in plants; and, carbon arriving in them only through the decomposition of the carbonic acid of the air, it is clear that vegetables, considered in a general sense, tend to diminish the quantity of carbonic acid in the atmosphere, and to increase that of oxygen. But the respiration of animals and combustion tending to produce just the contrary effect, the general stability of the constitution of the atmosphere is not perceptibly disturbed.

The sap altered by respiration in the leaves and other green parts, now descends into the stem and root, and is rendered subservient to the development of all the organs.

RECAPITULATION.

237. What are the two principal functions of plants, and the organs by which they are performed? Give a general account of the function of Nutrition, and enumerate its various stages. 238. What is meant by Absorption? By what organ is it chiefly performed? What other parts of plants imbibe moisture? How are succulent plants, which grow in dry sand, nourished? 239. Of what substances does the food of plants consist? From what sources is the carbon derived? What experiments have been instituted on this subject? Whence is the hydrogen, and the nitrogen of plants obtained? What minerals are found in the tissues of plants? 240. How may endosmose act in producing absorption? What effects have heat and light upon absorption? 241. What is the Sap? Of what is it composed? How are the various substances found in it supposed to be introduced or generated? 242. What becomes of the fluid absorbed by the roots? At what periods of the year is the sap most abundant? Is there any difference in the quality of sap obtained at different heights in trees? What becomes of the ascending sap? 243. Through what channels is the sap conveyed? 244. What are the causes of its progression? 245. What change is first undergone by the sap on its entering the leaves? What were the results of Hales's experiments? When the transmission of sap into the leaves is very rapid, what happens? How is it proved that the drops on leaves are not produced by dew? How does it appear that the stomata are the exhalant organs? 246. What circumstances are favourable to exhalation? Are succulent plants more readily dried? What proportion of the sap is exhaled? 247. What is meant by respiration? Explain the assimilating power of plants, which is in operation during the day. What alternate economy occurs during the night. Do plants give off carbonic acid during the night as well as during the day? How are plants increased in bulk? Explain the healthful action of plants upon the atmosphere. 248. How

is the green colour of plants produced? What is Chromule?
249. How does vegetable respiration affect the state of the air? What effect has the respiration of animals upon it?

CHAPTER XXII.

NUTRITION—(Continued.)

THE ELABORATED OR DESCENDING SAP. ITS PROGRESS DOWNWARDS. VEGETABLE SECRETIONS. ASSIMILATION.

250. *Descent of the Elaborated Sap.*—The crude, or ascending sap, having expended two-thirds of its amount by aqueous transpiration, and a slight proportion of its gases by respiration, is converted into a fluid capable of being assimilated by the various parts of the plant, and consequently of directly affording them nourishment. It then forms what has been called the *Nutritious Juice, Proper Juice, True Sap,* or *Descending Sap.* In this state it contains a large proportion of gum, sugar, or fecula, and is further submitted to modifications resulting in the formation of various substances, either to be retained or separated as useless. Owing to the manner in which the juices are intermixed, and on account of the great number of vegetable products contained in them, it seems impossible to determine the true nature of the elaborated sap. All these products are composed merely of different modifications of the same elements, namely, carbon, oxygen, and hydrogen; but the fluids of different species of plants present great differences in their palpable qualities; so that no particular modification can be assumed as characterizing the general sap, analogous to the blood in animals. In some plants the

sap is a white and milky juice, in others yellowish, in many limpid; and its properties are equally various.

251. *Descent of the Sap.*—The principal movement of the elaborated sap is in the inverse direction of that of the lymph or fluid absorbed by the roots. If a tight ligature be applied to the trunk of a dicotyledonous tree, or a ring of bark removed from it, the nutritious juices being unable to descend, accumulate above the ligature or ring, and there form a circular swelling, which becomes more and more prominent. It is further remarked, that the part of the trunk situated beneath the ligature ceases to grow, and that no new woody layer is added to those already existing, because the nutritious fluid is unable to reach it. This fact therefore proves, that it is to the descending sap that the growth of the plant is due. It circulates chiefly in the parts of the stem in which new layers are formed, or along the bark and alburnum. It covers the inner surface of the former, and the outer surface of the latter, with a fluid, which becomes more and more viscid, and then takes the name of *Cambium*. Presently traces of organization appear in this fluid, and there are formed in it new cellules and fibres, which gradually acquire consistence. This, as has been stated, is the mode of growth in the trees of our climates; but it does not appear that anything is known with precision regarding the descending sap in the stems of monocotyledonous trees.

252. If the *channel* of the ascending sap has been a matter of much uncertainty, that of the descending sap has occasioned at least equal perplexity. Mr. Rainey observes—"Now the only parts which connect the leaves of the exogenous plant with its branches, are cells, vessels, and intercellular tissue; and it has been shown that the descending sap does not pass along the last of these, that is, the intercellular tissue; it must, there-

fore, be conducted either by the cells or by the vessels. The cells being distinct one from another, surrounded by intercellular tissue, and having no openings of communication one with another, can scarcely be supposed to serve as conductors of a fluid; . . . and therefore the function of conducting the elaborated sap may fairly be inferred to be performed by vessels. Moreover, vessels are continuous passages extending from the leaves all along the branches and stem down into the roots, and *have large and extremely well defined openings of communication one with another,* and therefore possess all the necessary anatomical characters of tubes designed for the transmission of a fluid."—(*Experimental Inquiry.*) It remains only that we notice the elaboration which takes place in the root, and the *ascent of the elaborated sap,* in the early part of the year, before the leaves appear. This process is analogous to that of germination; as the starch deposited in the seed becomes converted into sugar and gum for the nutrition of the embryo, so the starch deposited in the root while the leaves were in active operation, probably undergoes a similar change, in the early part of the year, for the nutrition of the leaf-buds. The *ascent* of this elaborated fluid takes place from the roots into the vessels of the stem, thence into those of the branches, and lastly into the vessels of the developing leaf-buds. The cause of this ascent is endosmose—a process which has been already explained.

253. *Peculiar or Local Movements.*—The ascending sap and the descending sap cannot be supposed to be strictly confined within certain limits, as the organs through which they pass are contiguous, and, in whatever way it may be accomplished, a transfusion or lateral movement takes place. In the cells of certain plants, especially those of the genus *Chara,* a *Cyclosis* or cir-

cular movement of the fluid, rendered observable by the existence of opaque granules in it, is observed, the granules ascending by one side of a cell and descending by the other. Another kind of circulation was discovered by M. Schultes, who describes the proper juices of many plants as undergoing a complex kind of motion, in particular vessels, which occur in the root and stem, and appear to anastomose in their whole extent.

254. *Vegetable Secretions.*—The descending sap is not merely subservient to nutrition, but furnishes various matters which are secreted or separated from its mass, and afterwards elaborated by particular organs. Many of these matters are ejected, and constitute what are called *Excretions.* Whether they are to be considered as components of the sap, or secretions from it, there are four substances, closely allied in chemical composition, which are of very general occurrence: gum, sugar, fecula, and lignin.

1. *Gum* is a substance destitute of taste or smell, insoluble in alcohol, but forming with water a viscid fluid to which the name of mucilage is given. It is observed in various parts of plants, as in seeds, bark, and roots. The purest kinds are gum-arabic and gum-tragacanth.

2. *Sugar* is a substance having a sweet taste, and soluble in water, as well as more sparingly in alcohol. It is met with in most parts of plants. Several kinds are distinguished. That in common use as an article of food is obtained from a species of grass, the Sugar Cane, by expression and evaporation. The sugar of the beet-root, chestnut, and maple, is similar. When pure, this sugar crystallizes in a regular manner, and then forms candy-sugar. Grape sugar, which is extracted from the grape, gooseberry, apricot, and fig, has a different taste, and contains more water.

3. *Fecula* or *Starch* is a substance composed of organic

granules, which is extracted, by trituration in water, from the roots, tubercles, and stems of various plants, and chiefly from the seeds of wheat, barley, oats, and other cereal grasses. Each granule is formed of a membranous covering, and an inclosed substance of a gummy appearance. The fecula is deposited at the bottom of the water in the form of a white shining powder, destitute of taste or smell. It forms a mucilage with boiling water, and, if the solution is evaporated, a kind of jelly is obtained.

4. *Lignine*, which is also composed of granules, having an external pellicle, is contained in the elongated cells or vessels of the woody tissue of plants, and does not appear to answer any other purpose in the vegetable economy, but remains unchanged in the cells. It differs from gum, starch, and sugar, chiefly in containing a larger proportion of carbon.

255. *Other Vegetable Products.*—Besides these four substances, which appear to be the simplest modifications assumed by the nutritious materials found in plants, there are many others, of which the more remarkable are here mentioned. The *Fixed Oils* are combustible substances, insoluble in water, and forming soaps with alkalies. They occur in the fruits, and chiefly in the seeds of various plants, and are divided into such as thicken and become opaque when exposed to the air, as olive oil and oil of almonds, and such as dry without losing their transparency, like varnish, as linseed oil. Vegetable *Wax* differs from fixed oil only in being solid at common temperatures. It is seen on plums, oranges, and the leaves of the cabbage, in the form of a very fine glaucous powder; on the fruit of Myrica cerifera, and the trunks of some palms, in a thick layer; and it preserves plants from the injurious action of moisture. *Volatile Oils* are much more common, and are met with in the bark, leaves, flowers, and pericarps of plants. They re-

semble the fixed oils, but are distinguished from them by a strong smell, a slight solubility in water, and the property of being volatilized without decomposition. They are used in painting or as perfumes. Most scented substances or aromas owe their properties to these volatilized oils. They are found in the bark of the cinnamon, the leaves of the Labiatæ, such as Mint and Thyme, and the rind of oranges and citrons. *Camphor*, which is nearly allied to the Volatile Oils, is a solid, colourless, transparent, highly odorous, and inflammable substance, obtained by distillation from the wood of certain species of Laurel.

256. *Vegetable Products*, continued.—The *Resins* are dry, brittle substances, insoluble in water, soluble in alcohol, softened by a low degree of heat, and highly inflammable. Resins, mixed with volatile oils and benzoic acid, form the *Balsams*, which are inflammable and odorous. Of the former may be mentioned the resin of the pines, mastic, dragon's-blood, and copal ; of the latter benzoin, storax, and balsams of Peru and Tolu. *Caoutchouc* or *Elastic Gum*, which flows in the form of a milky juice from several trees of the equatorial zone, is neither a gum nor a resin, but a peculiar substance which is insoluble in water and alcohol, coagulates in the air, becomes brown, assumes the appearance of leather, and acquires an extreme elasticity. Plants contain *acid* principles, and others possess *alkaline* properties. The most remarkable vegetable acids are *Acetic Acid*, or pure vinegar, furnished by the fermentation of various liquors, and the distillation of wood ; *Malic* and *Citric Acids*, which are extracted from fruits, and particularly from the apple and lemon ; *Oxalic Acid*, which is found in the leaves of oxalis, in combination with potash ; *Tartaric Acid*, which occurs in the free state in the pulp of certain fruits, and in combination with potash in the juice of the grape,

when it forms cream of tartar; *Prussic Acid*, a very active poison, which is extracted from bitter almonds, and from the kernel of the peach, apricot, plum, cherry, and other drupes ; *Gallic Acid*, which produces a black colour, with red oxide of iron, and is found in gall-nuts, and in most barks of trees, communicating its astringent property to most of the vegetable substances which contain it, among others to the tannin used for preparing leather. Of the alkaline substances may be mentioned *Morphine*, which is contained in opium, or the juice extracted from the white poppy, and of which the salts formed by its combination with acids, especially acetic acid, are very dangerous poisons; and *Quinine*, which is extracted from Cinchona. Plants, moreover, contain various colouring matters, which are found sometimes in the roots, as madder; sometimes in the stems, as the colouring substance of Brazil wood ; sometimes in the leaves, as indigo ; or in the flowers, as the red of Carthamus.

257. *Adventitious Substances in Plants.*—Besides the numerous products of Secretion, resulting directly from the action of the elementary organs, there are substances which have been absorbed by the roots, or have resulted from the combination of these substances with the vegetable products. *Lime* is generally found in the ashes of plants, in the form of a carbonate, or in union with various acids. *Silica* also occurs in considerable abundance, especially in the stems of some monocotyledonous plants. The glossy pellicle on the surface of reeds, canes, and other grasses, contains a large proportion of it, insomuch that if two canes be rubbed against each other in the dark, they emit a light like that given out by the friction of two pieces of quartz. On the inner surface of the fistular joints of the Bamboo, a substance named *Tabasheer* is deposited, in plates or masses, at first moist like paste, but ultimately resembling semi-transparent

disintegrated opal. When a stack of corn has been burnt, the ashes are found fused into a partially vitrified mass, resulting from the silica and alkali contained in the straw. Salts of *potash* and *soda* are abundant in many plants, those of the latter in such as grow near the sea. Common Soda or Carbonate of Soda is obtained by burning several maritime plants, as *Salsola Kali* and *Salsola Soda*, as well as marine algæ, such as *Fucus vesiculosus* and *Fucus serratus*. These substances are so abundant in plants that they can hardly be considered as merely adventitious ; but various other products, such as metallic oxides and salts, that occur in small quantities in the ashes of plants, have probably been derived from absorption by the roots or leaves.

258. *Excretions.*—Many of the substances above enumerated are to be regarded as excrementitious, especially wax, which is found on the surface of fruits, gums, and resins, which exude from the bark ; also volatile oils and glutinous juices. Stinging plants, as Nettles, secrete an alkaline caustic juice, contained in a cellular bag, surmounted by a hollow bristle. When the bristle is pressed, the fluid passes through the tube, and is ejected into the wound, by a mechanism precisely similar to that of the poison fangs of serpents. Clammy substances are often secreted on the stems by glandules or glandule-tipped hairs. Among the most remarkable secretions are those discharged from the roots of plants, it being found that some give out acid, others milky, mucilaginous, or saccharine substances. It has been suggested by M. De Candolle that the theory of the succession of crops is to be sought for in this circumstance. It had been observed that some plants will not prosper in situations where others of the same kind had previously grown, and that certain plants succeed best when sown in ground previously occupied by certain other species. Now, among

the substances which act as poisons to plants, it has been found that most vegetable secretions are to be enumerated, and it is a general law that no plant is capable of digesting its own excretions. But, although the excretions of a plant may be noxious, not merely to its own species, but to others of the same genus or family, they may be harmless or even beneficial to plants of other families. It seems thus probable that, by a proper rotation of crops, the soil may be preserved in a state of fertility, without the application of much manure.

259. *Taste and Odour of Plants.*—The tastes of plants must depend upon the nature of their juices and the substances secreted from them. This subject, however, has received little attention, and the classification and nomenclature of tastes, as well as of smells, is merely empirical. Some parts or substances are tasteless, or nearly so, as membrane, mucilage, and resin; sweet tastes depend upon the presence of sugars; sour, upon that of acids; bitter, upon alkaline salts or extractive matter; astringent, on acids in excess; acrid, on volatile oils. The odours of plants depend chiefly upon the emission of an essential oil, which differs in the different species, being more or less volatile, and in various degrees miscible with water. The oil is stored in the stems and leaves, and when these parts are rubbed or bruised, the odour becomes more sensible. Heat generally renders the odours of plants more powerful, but sometimes disperses the odorous particles so rapidly that little smell is perceptible. Some flowers emit their odour only in the evening or at night, as is the case especially with those Cruciferæ, as the Wall-flower, that have a dingy brown colour. The nomenclature of scents is not more intelligible than that of tastes; they are sweet, aromatic, musky, fetid, alliaceous, acrid, nauseous, and oppressive. Very different impressions are made on different indi-

viduals by the scent of the same flower. Some odours make very deleterious impressions on persons of weak nerves, insomuch that death has sometimes resulted from them.

260. *Assimilation.*—The sap having been elaborated and conveyed to the different parts of the plant, is applied to the nourishment and development of its various organs. But of the manner in which this assimilation of the nutritious fluid takes place, it appears that nothing is known with precision. How the first cellules of the elementary tissue are produced, and in what manner they are increased or extended, have never been satisfactorily determined; for the various organs already exist in some degree of development before we can submit them to examination, and their extension cannot be traced in continuance with the necessary minuteness and attention. The process already described and that of assimilation go on simultaneously, and although we are sensible of the general results, we are unable to trace the progress of the parts in detail. Some suppose the tissue to be extended by the development of young cells within the old ones, which they rupture and replace; others think that the new cells originate from the minute granules or dots seen on the surface of some cells; and others are of opinion that the cells become divided by transverse partitions, the space between each pair of which becomes a new cell. The vascular tissue is supposed by some to be similar in origin to the cellular tissue, the vessels being merely elongated cells, or series of united cells. Others consider the new vessels as analogous to roots, and maintain that they proceed from the buds placed in the axillæ of the leaves. Some parts of plants once formed appear to be incapable of receiving further development. Of this kind is the pith, which is enclosed in a cylinder of tissue that prevents its exten-

sion. The woody layers also remain stationary, the only change effected upon them being the filling up of their cavities by the deposition of lignine and other substances. It appears to be by the cellular or parenchymatous tissue that the development of plants chiefly takes place. The pith, then, filled with fluid, is the first part that appears when the stem shoots up. Scales, young stamens, and pistils, and the tips of the radicles, are composed of it; in all cases of wounds, as in pruning, propagating by slips, or grafting, it is the part first generated.

261. *Pruning.*—When a limb or branch is cut off, for the purpose of improving the timber of the stem, or for giving the plant a more agreeable form, a portion of the inner parts of the woody layers is exposed. These being incapable of generating new tissue, would remain exposed, and decay, were it not for the newer tissue round the edge of the wound, which gradually extends over its surface, so as to meet in the centre, forming a complete cicatrix. In dicotyledonous trees and shrubs, as has already been stated, the growth takes place at the part where the outer layer of wood and the inner layer of bark are in contact. Now, in the case adduced, the wood covered over by the extension of the parenchymatous tissue of the bark produces no new layer, and the layer of wood formed over it does not adhere to it. As the growth of the tissue that covers the wood depends upon the returning sap for its nourishment, the branch must not be lopped at a distance form the trunk, otherwise it will not heal over, there being no leaves upon it to furnish a supply of elaborated sap, and whatever descends from the stems is expended in developing the tissue and lower parts of the stump of the amputated limb. Since the surface of the cut never adheres to the new tissue formed over it, and the wood is always more or less blemished by pruning, it is obvious that the opera-

tion should be performed when the branches are young, or even when only in bud ; but if this cannot be done, the cut should be made quite close to the trunk, and its surface protected by some compost to prevent any degree of decomposition, till it is healed over.

262. *Grafting.*—The operation of grafting also shows the superior vitality of the parenchymatous tissue, and proves that the nutritious fluid circulates in the more external parts. The object of this process is chiefly to propagate particular varieties of fruits, which cannot be obtained from seed. A bud or twig of the tree to be propagated is united to another tree on which it grows, the fruit produced continuing to be similar to that of the original tree, and not of the stock on which it has been grafted. This kind of union takes place between individuals of the same species, between species of the same genus, or between species of different genera of the same natural family, and the more nearly the two species are allied, the more readily do they unite. The operation is performed in various ways. When the branches of two or more trees are united, the process is called *Grafting by approach.* Usually in this case two plants are placed near each other, and their branches grafted. When they have become perfectly united, one of them is separated from its stem, and left to grow on that of the other. Another way is to cut a shoot from a tree, and attach it to the extremity of the branch of another tree prepared for the purpose by being cleft or otherwise cut. This method is called *Grafting by slips.* A common practice also, called *Budding,* is to remove a bud along with a portion of the surrounding bark, cut out a corresponding piece from another tree, and insert the bud in its place. In all cases the alburnum and liber of the two trees must be placed in correspondence. The graft is secured from displacement or access to air for some time, and complete

union takes place. In this manner are multiplied different kinds of fruits, as apples, pears, and plums, each of which is only a variety accidentally raised from seed, but is not capable of being further propagated in the same way. It is thus apparent that in dicotyledonous trees the principal seat of the vital operations is in the liber, alburnum, and intervening cambium. Two of the theories which explain the growth of these trees may here be mentioned. One of them, of which the author is M. Du Petit-Thouars, attributes the successive formation of the woody layers to the development of the buds; the other, or M. Mirbel's theory. to the cambium.

263. *Du Petit-Thouars's Theory.*—The considerations upon which this theory are founded are the following: —Buds are the first perceptible phenomena of vegetation: there is one in the axilla of each leaf; but it is only in Dicotyledonous Plants, and in the Gramineæ, that the buds are apparent, they being in other plants latent, and consisting merely of a vital point, which, in certain circumstances, is capable of being developed. Buds, by their development, give rise to shoots, which are furnished with leaves, and generally with flowers. Each bud is, in some measure, independent of the rest, and may be considered as analogous to the embryo of a seed. Buds may thus be called *Fixed Embryos,* in opposition to seeds, which are *Free Embryos.* If we examine the interior of the buds on a shoot or young branch, we find that it communicates directly with the pith, which is at first green, and filled with sap, from which the buds derive the first materials of their development. Having thus supplied the buds, the internal parenchyma dries up, and becomes converted into pith, properly so called. As soon as the buds appear, they obey two general motions, an ascending and a descending, being in this respect similar to the seeds. The layer of cambium, situated

between the wood and the bark, is analogous to the soil in which the seed grows. The bud sends upwards a shoot or young branch, and downwards into the cambium fibres, or radicles, which, gliding between the liber and alburnum, descend to the lower part of the plant. In their course downwards these fibres meet those which descend from other buds, unite with them, anastomose, and thus form a layer, which acquires consistence and solidity, and forms each succeeding year a new woody layer. The liber, once formed, does not change its nature, and undergoes no transformation. This theory, which is very ingenious, and remarkably simple, has not been generally adopted.

264. *Mirbel's Theory.*—If we examine a young branch at the period of vegetation, we find between the liber and alburnum a layer of fluid, at first limpid, but gradually thickening and acquiring consistence. This fluid, the *Cambium*, is the descending sap, mixed with part of the proper or secreted juices. As it thickens, filaments are seen to form in it, and it gradually assumes the appearance of vegetable tissue, the development of the layer continuing during the whole period of the development of the buds. In this manner a new layer of woody tissue is formed each year in the trunk of dicotyledonous trees, being produced by a part of the cambium, which is organized, and becomes solid. The alburnum formed the preceding year acquires more density, and changes into wood, properly so called. A thinner layer, also formed from the cambium, is added to the liber or inner bark. This theory is the one most generally adopted by writers on vegetable physiology.

265. *Continuance of Growth.*—Although an apparent cessation of the development of plants takes place in winter, after the leaves have fallen, yet even during that season some slight enlargement of the buds is observed,

and the sap is not entirely quiescent. When spring advances, the increased temperature gives a continued impulse to the vital powers; the sap flows with rapidity towards the twigs, and the buds are quickly developed. As the summer advances, the motion of the fluids gradually diminishes. In autumn, the buds which have been formed in the axils of the leaves continue to grow, while the other herbaceous parts decay; and thus there is caused a renewed, but less vigorous motion in the sap, which ceases as the cold increases. As the fluids are in a state of torpidity, and the development of the parts arrested, in winter, trees or other vegetables may, at that season, be transplanted with less injury than at any other.

266. *Summary of Nutrition of Organized Beings.*—The difference between nutrition and reproduction consists in this—the phenomena of the former relate to the development and support of the *individual,* those of the latter to the perpetuation of the *species.* In each kingdom of organized being, the vegetable and the animal, nutrition comprises *seven stages,* or classes of phenomena, which may be briefly represented as follows:—

(1.) In both kingdoms the aliment, liquid or solid, is introduced into the system by one or more fixed orifices. In most animals the orifice is single, the mouth; exceptions occur in rhizostomes, in which there are several mouths in the form of suckers. In plants, the orifices are usually numerous, being composed of the spongelets, or terminations of the fibres of the root. In animals, the food is liquid and solid; in plants, it is only liquid.

(2.) The aliment, when introduced, is conveyed into organs specially provided for the purpose of elaboration. In plants, it is conveyed directly by the root and stem to the foliaceous parts, where it is brought into contact with the atmosphere. In animals there are some special

cavities, as stomach and intestines, in which the aliment undergoes a preliminary modification—the unnutritive portion is rejected as excrement, the remainder is conveyed onward in the form of chyle.

(3.) The liquid aliment—the chyle in animals, the sap in plants—is conveyed to the surface, where it is brought into relation with the external air. A portion of it passes off by evaporation, in both kingdoms, by transpiration from the entire surface ; or, in another sense, by abundant transpiration in the lungs of animals, and by exhalation by the leaves in vascular plants.

(4.) The alimentary matter, having acquired greater consistency, is modified chemically by contact with the atmospheric air. In animals there is an increase of *oxygen ;* in plants, of *carbon.* This difference corresponds with the energy, activity, and mobility of the former, compared with the fixity and stationary condition of the latter. In the higher animals and plants this chemical effect takes place in the lungs, branches, and leaves ; in the lower, in air-cavities, where the air is exposed to the fluids, or by the whole external surface.

(5.) The alimentary fluid, modified by the preceding operations, has become highly nutritive. In animals it is now *blood;* in plants it is *cambium.* It is now deposited in the tissue by the function of circulation.

(6.) A portion of the elementary molecules, contained in the sap, is so deposited as to be capable of being conveyed, in the sap or lymph, from one organ to another. This is the case with the fat in animals ; with tubers, fleshy cotyledons, receptacles, and other fleshy deposits in plants.

(7.) Some peculiar organs, called *glands,* are capable of separating from the alimentary liquid substances of very variable properties. These are *secretions.* Of these, some are expelled, and termed excretions, as the urine ;

others continue in the system for useful purposes, as the bile, the saliva, &c. This distinction is more obscure in plants.

Hence, we conclude that—

AN ANIMAL
is an Apparatus of Combustion;

Possesses the faculty of Locomotion;
Burns Carbon,
Hydrogen,
Ammonium;
Exhales Carbonic Acid,
Water,
Oxide of Ammonium,
Azote;
Consumes Oxygen,
Neutral azotized matters,
Fatty matters,
Amylaceous matters,
Sugars, gums;
Produces Heat,
Electricity;
Restores its elements to the air or to the earth;
Transforms organized matters into mineral matters.

A VEGETABLE
is an Apparatus of Reduction;

Is fixed and stationary;
Reduces Carbon,
Hydrogen,
Ammonium;
Fixes Carbonic Acid,
Water,
Oxide of Ammonium,
Azote;
Produces Oxygen,
Neutral azotized matters,
Fatty matters,
Amylaceous matters,
Sugars, gums;
Absorbs Heat,
Abstracts Electricity;
Derives its elements from the air or earth;
Transforms mineral matters into organic matters.

RECAPITULATION.

250. What names are given to the elaborated juice? Are its general characters easily defined? Does it vary in its qualities? 251. What course does the sap now take? How may its descent be proved? Where does it chiefly circulate? 252. By what organs does this sap descend? What arguments in proof of this have been employed? At what period does the elaborated sap ascend in a plant? For what purpose does it ascend? Is there any analogy between this process and that of germination? What is the Cambium? What change stake place in it? 253. Does the descending sap follow a strictly defined course? What motions are observed

in the cells of Chara? What kind of circulation has been seen in the proper juices? 254. What are the substances most generally found in the sap? Give an account of Gum. What are the characters of Sugar? Describe Fecula. To what use is Lignin peculiarly applied? 255. Mention some other vegetable products. What are the general characters of the Fixed and Volatile Oils? Mention some plants that produce wax. How is Camphor obtained? 256. What is the nature of Resin? Describe Caoutchouc. What are some of the most remarkable vegetable Acids? Mention some Alkaline substances. In what parts are colouring matters contained? 257. What adventitious substances are contained in plants? What is Tabasheer? Do many plants contain potash? In what kinds is soda found? 258. What substances may be considered as excrementitious? How do the excretions of the roots of plants account for the rotation of crops? 259. Upon what do the tastes of plants depend? What is the principal cause of their odours? 260. How are the elaborated juices applied to the development of the organs? Mention the three different opinions regarding the development of the cellules. How is the vascular tissue supposed to be formed? What parts remain stationary after being formed? On what tissue does the growth of plants chiefly depend? 261. What is meant by Pruning? What takes place when a branch is cut from a tree? Should branches be cut off short, or at some distance from the trunk? 262. What is Grafting? Describe its three principal kinds. What parts must be placed in correspondence? What results? 263. What is the theory of Du Petit-Thouars with regard to the growth of Dicotyledonous trees? 264. State the theory of M. Mirbel on the same subject. 265. Is the progress of vegetation entirely arrested during winter? At what season may vegetables be transplanted with least injury? 266. What is the precise difference between Nutrition and Reproduction? Trace the analogies presented by the two organized kingdoms in reference to the seven successive stages of nutrition.

CHAPTER XXIII.

FUNCTION OF REPRODUCTION.

PROPAGATION BY DIVISION. REPRODUCTION, PROPERLY SO CALLED. FLORATION. FECUNDATION. MATURATION. DISSEMINATION.

267. *General Idea of Reproduction.*—The process by which the vegetable prepares the means of continuing its specific form, by generating new individuals, is named *Reproduction.* The term *Propagation* is of more comprehensive meaning, for it includes not only the natural means of continuing the species, but also those to which recourse may be had by cultivators of plants. Naturally, also, there are two modes by which vegetables are propagated: Reproduction without fecundation, and Reproduction by fecundation. Plants may be multiplied by means of germs, which are formed on all parts of their surface, and are developed by the action of the nutritious fluids, when in circumstances rendering them capable of receiving their influence. These latent buds or germs may form either roots or aerial shoots, the former being produced when a part in which the juices abound is surrounded with moist soil, or protected from air and light; the latter, when it is exposed to the influence of these agents. Germs of this kind, as well as Buds, properly so called, and Bulbils, are parts of a plant which may be separated, and yet continne to live, and have an independent existence. They give rise to a continuation of the individual, not merely in regard to its general resemblance to the species, but even in all the peculiarities by which it is distinguished from other individuals. Another

mode of propagation is by *seeds,* which are impregnated ovules, subsequently developed. The two modes may be distinguished as Propagation by *Subdivision,* and *Reproduction,* properly so called.

268. *Propagation by Subdivision.*—When the descending sap is increased in quantity, or its motion diminished in any part, there are evolved buds, some of which produce branches, others flowers. Thus, in the axils of all the leaves the sap is somewhat retarded in its progress, and there is naturally developed there a bud, which changes into a branch. This branch may be considered as a distinct individual, which has been produced upon another individual, from which it derives its nourishment, but which may be separated from it, and obtain nourishment either from the soil in which it is placed, or from another individual to which it may be affixed by grafting. This process of grafting, which has already been spoken of, § 262, and which consists in transferring a bud or branch from one individual to another, is of great use to cultivators, as it serves to perpetuate varieties, which could not be reproduced by seeds; economizes time by quickly procuring a great number of trees, which are with difficulty multiplied by other means; and accelerates the fructification of certain plants by several years. Many plants may be propagated by slips or cuttings, a portion of a twig being separated from the parent plant, and placed in the ground, where it takes root. Individuals are also multiplied by bending a branch and covering it with earth, into which it sends roots; or by surrounding with earth the extremity of a branch, after applying a ligature to it, to make it push out roots, after which the branch is cut off. The tubers which form on the roots of certain plants, on being removed and again planted, produce new individuals, as in the Potato. When a plant, as the Strawberry, sends out

shoots or runners, § 54, the buds at their extremity take root and develope leaves, after which the runners decay, or are cut across, and thus new individuals may be obtained. Many plants, as elms and poplars, throw up suckers from their roots, at some distance from the trunk, which, under favourable circumstances, may become distinct trees. But although many plants may be propagated by these methods, all those which produce flowers secure the continuation of their species by a different process.

269. *Reproduction.*—By *Reproduction*, properly so called, is meant the formation of seeds, containing the germs of new individuals. To this function are subservient the Perianth, Stamens, and Pistils. A seed is a germ or embryo, which having been formed upon the parent plant, and for some time derived its nourishment from it, has become free, after being fecundated, or in other words, after receiving the principle of life, or the power of becoming developed under particular circumstances. The seed, which separates from the parent plant, is furnished with proper envelopes and with organs of nutrition. It is not, like the bud or bulbil, a continuation of the same individual; but a new individual resembling that from which it has been derived only in the parts essential to the species. Reproduction by means of seeds comprehends several distinct periods or processes, as,—

(1.) *Floration*, or the development of the flower.
(2.) *Fecundation*, or the function of the pollen.
(3.) *Maturation*, or the development of the fruit.
(4.) *Dissemination*, or the dispersion of the seeds.

270. *Floration.*—Flowers are formed in some plants long before they appear externally: in Hyacinths, the racemes exist in the bulb before the leaves are developed; and in Palms, the rudimentary régimes (see p. 75), exist

one, two, or even, it is said, seven years before they are developed exteriorly. The causes of the production of Flowers are unknown. Some plants flower in a few weeks after germination, others take some months, and others require several years. Flowers are not, as was long supposed, mere ornaments to plants, for they contain the organs essential to reproduction, namely, the stamens and pistils. When first distinguishable, their parts are in a rudimentary state, especially the perianth, which for some time continues to enlarge much less rapidly than the stamens. All the organs, however, gradually enlarge until expansion takes place. In the bud, the calyx usually covers and protects the other parts, the corolla is generally closed over the stamens and pistils, the anthers are developed, and burst at the period of expansion, or presently after.

271. *Stimulants to Flowering.*—The period of flowering is accelerated by an increase of temperature, and retarded by cold. These causes also operate in determining the buds to assume the character of leaf-buds or flower-buds. Superabundant moisture retards the flowering, and renders the flower-buds less numerous, as in the case of a too profuse supply of nutriment, or of an unusual excitement by heat; hence the fruit-trees of temperate climates, on being carried to the tropics, often vegetate vigorously, although they become barren. It seems to be a general law that the number of flowers produced by a plant is in some measure proportional to the quantity of nutritious matter which it has accumulated. Thus, after a warm and bright summer, during which the branches have acquired only a moderate development, and nutritious matter has been stored up, a profusion of flowers is produced. There appears to be an *antagonism* between the reproductive and the nutritive functions. In flowering plants, it is well known

that an excessive supply of nutriment will cause an evolution of leaves at the expense of the flowers, so that what would have been *flower-buds* are converted into *leaf-buds;* or the parts of the flower essentially concerned in reproduction, as the stamens and pistil, are converted into foliaceous expansions, as in the production of *double flowers,* as they are called, from single flowers, by cultivation. In the Algæ, which are plentifully supplied with water, the dimensions attained by the nutritive parts of plants are exceedingly disproportionate to the reproductive apparatus; while in the Fungi, the whole plant seems made up of reproductive organs, and as soon as these have brought their germs to maturity, it ceases to exist.

272. *Periodicity of Flowering.*—Different species flower at different periods of the year, varying to a considerable extent, however, according to the state of the weather, and the degree of temperature. Thus, the Christmas Rose flowers in January, the Snowdrop in February, the Crocus in March, the Primrose in April, the Lily of the Valley in May, the Wood-Vetch in June, the Yellow Iris in July, the Tansy in August. The reasons of this variation we are unacquainted with; and, when we attribute it to the peculiar character of the species, we merely use words to conceal our ignorance. Owing to some peculiarity in the constitution of individuals, they flower earlier or later than others of the same species; and in both cases, advantage is taken of the circumstance by propagating peculiar races, which afford the cultivator a longer succession of crops. After producing a very abundant crop, which has exhausted the nutritious matter prepared in the stem, few flowers are produced the next season; and thus, apple and pear trees usually have alternate years of productiveness and comparative sterility. Many plants, as the Elm and

Alder, flower before producing leaves; but the greater number, after. Sometimes, when the leaves have been destroyed in summer by drought or insects, a second crop of flowers is produced in autumn. The *period of flowering* in plants is analogous to that of puberty in animals. Herbaceous plants flower in the first or second year, rarely later; woody plants, generally later; and this protracted period corresponds with their tardier growth and longer existence. The flowering period is earlier in warm than in cold climates; beyond a certain geographical limit, it occurs not at all.

273. *Horary Expansion of Flowers.*—The flowers of particular species of plants open at certain periods of the day, some in the morning, others at noon, and others in the evening. Most plants, however, appear to have no determinate period in this respect, their flowers, when once expanded, continuing open until they decay. Linnæus named those flowers *Ephemeral* which open at a particular time, and wither in the course of a day; and *Equinoctial*, such as open and close several days in succession at the same hour, some of them being diurnal, and others nocturnal. He constructed tables, which he fancifully termed *Flora's Time-pieces, Horologia Floræ*, to show the hours of expansion of various flowers. Thus:

Tragopogon pratense, opens from	3 to 5.
Papaver nudicaule, . .	at 5.
Hypochæris maculata, . .	6.
Nymphæa alba, . . .	7.
Anagallis arvensis, . .	8.
Calendula arvensis, . .	9.
Arenaria, ...	9, 10.
Mesembryanthemum, . .	11.

274.—*Functions of the Perianth.*—The calyx and corolla, when present, obviously serve to protect the sexual organs. The petals usually fall off before the

fruit is matured, but the calyx often remains, enlarges, and covers the pericarps. Sometimes the perianth forms appendages of various kinds to the fruit, as in the *Compositæ*, in which the calyx constitutes the pappus, § 137. As no part of a plant can be intended merely for ornament, the corolla must answer some important purpose with reference to the production of the seed; but the functions of the perianth are little known, and as it is sometimes absent, it is imagined by some to be in a manner unessential, although even in such cases its office may be supplied by the glands or other parts. It has been conjectured that the petals and nectaries secrete a fluid intended for the nourishment of the anthers and ovules; and this process has been compared to that of germination, to which it bears a further analogy by the development of heat. This phenomenon is most remarkable in Arum, as has already been mentioned, § 234.

275. *Fecundation.*—When the flower has attained a certain degree of development, the pollen formed by the anther falls upon the stigma, and thus causes the fecundation of the ovules contained in the ovarium or lower part of the pistil. It is easy to prove that the action of the pollen upon the pistil is absolutely necessary for the fecundation of the ovules and the production of the seeds which are developed in that organ. 1. In *diœcious* plants, as the Poplar and Bryony, the stamens and pistils are on different individuals; and it has been found that the pistils do not fructify, or at least do not yield fertile seeds, without the agency of the pollen, as is evident when the staminiferous are separated from the pistilliferous plants. 2. In *monœcious* plants, as the Maize, in which the stamen and the pistils occur in different flowers, if the staminiferous flowers be removed, the pistilliferous will not produce fertile seeds. 3. In *artificial fecundation*, the pollen of a plant is placed upon the

stigma of another plant closely connected with it, and seeds are produced as in the natural course. It has been known to the people of the East, from time immemorial, that the Date Palm, which is diœcious, will not perfect its fruit unless some of the staminiferous individuals are cultivated in the vicinity of the fruit-bearing trees, or unless bunches of the male flowers should be suspended near them. In Egypt, and other Eastern countries, the female trees only are cultivated, and bunches of the male flowers are brought annually from the deserts. It is stated that when the French were in Egypt, in 1800, the inhabitants were prevented from procuring the blossom, and a general defect of the date crop ensued. Another proof is derived from the production of *hybrids;* for if the stamens of a flower be removed, and its pistil impregnated with the pollen from another plant of a different species of the same genus, the seeds will be matured, and on germinating will produce plants having characters intermediate between those of the two species. It is thus obvious that the stamens and pistils are the sexual organs of plants.

276. *Sexes in Plants.*—The distinction and uses of the stamens and pistils were even in some degree known to various individuals before the time of Linnæus, who, however, was the first to demonstrate in a satisfactory manner the sexes of plants, or at least, to bring the subject more particularly into notice, by employing the sexes as the basis of his classification. However, the existence of stamens is not necessary in all plants to produce the germs of new individuals; for in Ferns, Lichens, Fungi, and other flowerless plants, male and female organs are not discoverable. It has been alleged, too, that Hemp and Spinach sometimes produce fertile seeds without the contact of pollen; but even should this occasionally be the case, it would not militate against

the general law, for in these diœcious plants some male flowers might exist among the female, and the pollen is often wafted by the winds to almost incredible distances. Thus, it is said that in 1805, a female date palm at Brindes, which regularly flowered, but never bore fruit, was fecundated by a male plant of the same species, thirty miles off, at Otranto, which had then only attained a sufficient height to overtop the trees in its neighbourhood, and thus allow its pollen to be dispersed.

277. *Formation of Pollen.*—The cells of the anthers are at first filled with a mass of cellular tissue, in each vesicle of which are one or more grains of pollen. These grains gradually enlarge, and at length rupture the vesicles, when the remains of the cellular tissue form loose shreds or fibres intermixed with the pollen. Each grain is generally composed of two membranes, of which the outer presents various appearances, while the inner is an extremely delicate pellicle. The granules, which it contains, are of various forms, being spheroidal or cylindrical. The grains themselves appear to have no attachment to the walls of the anther, and the granules in the fovilla often exhibit a rotatory motion.

278. *Protection of Pollen.*—When matured pollen is placed in water, it presently dilates, bursts, and emits a mass of granules. It is therefore necessary that it should be protected from moisture. In many cases the anthers are matured before the corolla opens, as is the case especially in all the Compositæ. Plants that grow in water elongate their peduncles until the flowers reach the surface, where they float, as in *Nymphœa*, or emerge to a considerable height, as in *Alisma*. In *Zostera marina*, the flowers, although developed under water, are placed within a cavity filled with air, and are thus efficiently protected. Perhaps the most remarkable instance of this protection of the pollen from the action of water,

is that exhibited by an aquatic plant, *Vallisneria spiralis*, a native of the south of Europe. It is diœcious, and grows at the bottom of the water. The female flowers are borne on peduncles several feet long, and twisted in a spiral manner, which allows them to be elongated or shortened. The male flowers, on the contrary, have very short peduncles. At the period of fecundation, the female flowers ascend to the surface of the water to expand, the male flowers detach themselves from their peduncles, expand at the surface, situated around or intermingled with the female flowers. Soon after fecundation is effected, the female flowers, by the contraction of their peduncles, are drawn back into the water, and there perfect their seeds.

279. *Dispersion of Pollen.*—When the pollen is matured, it bursts the anthers, escapes, and is scattered around. The stigma, which is adapted for receiving it, by being moistened with a clammy fluid, or furnished with filaments, is so placed, with reference to the anthers, as to insure the pollen falling upon it. Thus, sometimes when the pistil is much longer than the anthers, the flower droops; when it is shorter or equal, the flower is erect. Some flowers incline upwards, others downwards, when fecundation is about to take place, so as to put the stigma in a proper position for receiving the pollen. To favour the emission of the pollen, and its reception by the stigma, the fecundating organs perform very remarkable motions. Frequently the anthers open by the side of the pistil, with a kind of explosion, and thus cast the pollen upon it; the stamens sometimes approach the pistil at the time of emission, or bend their filaments so as to place the anthers over the stigma; or the pistils themselves incline toward the stamens. Numerous other contrivances, contributing to the same general effect, might be mentioned. The pollen is dispersed

partly by the elasticity of the anthers in bursting, partly by its weight, and partly by the action of the air. In diœcious plants especially, when the male plants are often placed at a great distance from the female individuals, the dispersion is operated by the winds. Dry weather is necessary for the free dispersion of the pollen, and sometimes, when the rains are heavy and continued, the process is rendered defective.

280. *Action of the Stigma.*—The grains of pollen which have fallen upon the stigma adhere to the glutinous fluid with which it is covered. After they have remained for some time there, the outer coat of each grain bursts, and the granules, contained in the delicate inner membrane, are protruded. This membrane, now termed the *pollen-tube,* contains, as has been stated, a liquid, the *fovilla,* in which are numerous pollen-*granules.* The pollen tubes penetrate between the vesicles of the cellular tissue of the stigma, rapidly increase in length, extend down the style, make their way into the cavity of the ovarium, traverse the placenta, and surround the ovules. Each pollen-grain may emit a different number of these tubes or vermiform appendages ; there may be only one, or two, or three, as in the triangular pollen of Onagraceæ ; Amici thinks that one grain may emit from ten to thirty of these tubular bodies. At this period the stigma has been compared to a velvet pin-cushion, with pins inserted into it, the pollen-grain representing the head of the pin, the tube its stem. Amici supposes that the pollen-tubes extend throughout the entire length of the style to the placenta which bears the ovules. Brongniart, on the contrary, says, that after penetrating more or less deeply into the style, they burst, and that the granules pass freely by the intercellular spaces to the ovules.

281. *Theories of Fecundation.* — The analogy which subsists between the *granules of the fovilla* and the *sper-*

matic animalcules of animals, has given rise to three theories of fecundation:—1, the germ is furnished by the male organ, and nourished by the female; or, 2, it is produced by the female, and developed by the stimulant action of the male; or, 3, it is the result of a material combination of elements produced by both. The last theory is that of Buffon, and accords with the fact that the product partakes of the nature of both parents; the second explains the development of seeds without fecundation, as observed by Spallanzani in diœcious plants; the first agrees best with the results of positive observation.

282. *Schleiden's Views.*—Schleiden published his views in 1837. He believes that the passage of the pollen-tubes from the stigma to the ovulum is the general process in the fructification of phanerogamous plants; that one, seldom several, of these tubes traverse the intercellular spaces of the nucleus; and that the tube which reaches the embryo-sac presses it forward, indents it, and then appears like a cylindrical bag, forming the commencement of the embryo, which, therefore, is stated to be nothing more than a cell of the leaf-parenchyma ingrafted upon the summit of the axis. According to this view, the embryo is formed by the pollen-tube and the indented embryo-sac; and in plants whose ovula contain several embryos, there will be just as many pollen-tubes present as there are embryos; whence there is derived the important conclusion that the two sexes of plants have been named altogether erroneously, each pollen-grain being the germ of a new individual; that the embryo-sac, on the contrary, should be considered as the male principle, which only determines dynamically the organisation of the material substratum.

283. *Meyen's Views.* — In opposition to Schleiden's views, Meyen states—1, that, in many cases, no pollen-

tubes have been observed during impregnation; and, 2, that, in many cases, the embryo-sacs are wholly wanting. He observes that, in most cases in which embryo-sacs occur, they are formed out of the apex of the nucleus, and grow upward to meet the pollen-tube; that the union of the pollen-tube with the apex of the embryo-sac is the very *act of impregnation;* that, after this union, there originates, in some cases, probably by the reciprocal dynamical action, a small protuberance at the place of union, which grows larger and larger, becomes filled with a turbid, slimy substance, and, separating itself from the pollen-tube, becomes a vesicle, which very soon expands in length, and grows deeply into the embryo-sac. This vesicle he terms the *germ-vesicle,* and considers it the first product resulting from the sexual action which the pollen-tube exerts on the apex of the embryo-sac. The germ-vesicle is not the result of a violent irruption of the pollen-tube into the embryo-sac, whose membrane would thereby be indented; but it is *formed of the substance of the two cohering membranes,* viz., that of the end of the pollen-tube, and that of the apex of the embryo-sac.

284. The *germ-vesicle* is nourished by the substance in the interior of the end of the pollen-tube, and by that in the interior of the embryo-sac; and from the union of these two substances and their innate formative properties, results the new product, viz., the base for the future embryo. There is no ejaculation of the fructifying contents of the pollen-tube into the cavity of the embryo-sac, but the fructifying substance passes, in very slight quantity only, into the forming germ-vesicle; soon after which, this free communication of the originated germ-vesicle with the pollen-tube ceases, by a constriction resulting from the formation of a diagonal septum. Upon this, in most cases, the end of the pollen-tube shrivels,

and very soon its former communication with the embryo-sac ceases entirely.

285. The *germ-vesicle* now expands in length, growing up into the depth of the embryo-sac, and usually represents a cylindrical tube, from whose end a simple globular cell then separates, which is the young *embryo*. The other remaining part of the cylindrical tube forms the *funiculus* of the embryo, assuming in different plants various forms and structure. After the formation of the young embryo, the funiculus generally dies off, and disappears, without leaving a trace behind it.

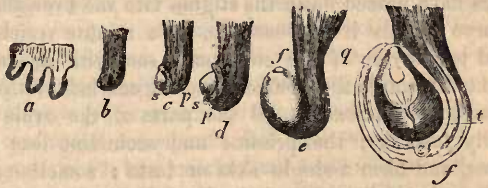
286. *Conclusions.* — The following conclusions are drawn from the observations above detailed:—1. *The embryo, in all cases in which it is formed in the interior of the embryo-sac, does not proceed directly from the pollen-tube,* but is formed at the extremity of an organ, subsequently serving as it funiculus, which originates from the prolongation and further development of the germ-vesicle. 2. *The embryo, on its first appearance, is nothing more than a simple globular cell, and thus presents the form and structure of the simplest plant.*

287. *Maturation of the Fruit.*—When fecundation is accomplished, the nutritious fluids which were equally distributed among all the parts of the flower cease to supply the stamens, then the corolla, often also the styles, and the calyx. The stamens and corolla thus shrivel and fall off, as do the style and stigma, and in many cases the calyx. The ovarium, to which the fluids are now exclusively directed, becomes developed, and assumes the name of *Fruit.* From the time when it thus begins to enlarge, until the seeds are perfected, is the period of *Maturation,* or of *Fructification,* properly so called.

288. *Development of the Ovules.*—When the *Ovules* are first seen, they are small protuberances arising from the surface of a cavity in the ovarium, and present no

distinct traces of organization, (Fig. 14, *a*). Soon after they elongate, *b*, *c*, *d*, and are found to consist of an internal part, or *nucleus*, composed of cellular tissue, and of *two coats*, *p*, *s*, by which the nucleus is partially invested. These coats gradually extend, so as at length to cover the nucleus, leaving only a small orifice, named the *Foramen*, *e*, *f*. The outermost coat is named *Primine*, the inner *Secundine*. The nucleus itself is composed of two, sometimes three sacs; the outer, or *Tercine*, *f*, *t*, thick and fleshy; the inner, or *Quartine* *q*, delicate.

(Fig. 14.)



As the ovule enlarges, it changes its position. The apex, which at first was on the side of the ovule, opposite the part by which it is attached to the ovary, is brought close to its base. The place at which the secundine is attached to the primine, and which is named the *Chalaza*, *z*, is distinct from the place where the *podosperm* or *funiculus* is attached to the primine. The vascular

(Fig. 15.)

tissue which passes through the podosperm extends through the substance of the primine, from the hilum to

the chalaza, forming a fasciculus named the *Raphé*. When the hilum and the chalaza are contiguous, and the foramen is at the other extremity, the ovule is said to be *Orthotropous*, (Fig. 15, *o*). This is the case with all ovules in their earliest stages. When a greater development of the integuments and nucleus takes place on one side than on the other, the ovule becomes bent, and is said to be *Campylotropous, c.* When the chalaza is distant from the hilum, so that the position of the ovule is reversed, it is named *Anatropous, a.*

289. *Progress of the Seed.* — Soon after the pollen-tubes have passed down the stigma into the ovarium, the embryo makes its appearance, as a minute vesicle, affixed to the top of the embryonic sac, with its radicle directed towards the foramen, and the cotyledons directed towards the chalaza. All the parts of the ovule gradually increase; the primine and secundine lose their juices, and form a single skin or testa ; sometimes the nucleus itself becomes similarly exhausted ; and sometimes nutritious matter is deposited within the tercine, or outer membrane of the nucleus. This nutritious matter, or *amnios,* in many cases is not entirely absorbed by the ovule, but remains, and constitutes the *albumen.* The embryo continues to increase, while the envelopes diminish, and ultimately forms the greater part of the seed, which, on attaining maturity, consists of the embryo, endosperm or albumen when present, and a single covering, the *episperm* or *testa,* composed of the remains of all the coats blended together. Should some of the ovules not be impregnated they soon wither, and in ovaries containing numerous ovules it sometimes happens that only one ovule is perfected, as in the Oak and Horse-Chestnut, of which the pericarps originally contain several. The mature seed has already been described, § 190.

290. *Progress of the Pericarp or Fruit.*—While the ovules gradually enlarge, the pericarp acquires a corresponding development, becoming more and more leathery, woody, cartilaginous, or membranous, and changes from green to brown or white. In many cases the pericarp increases in a much greater ratio than the seeds, becomes succulent, acquires various bright colours, and then constitutes what is popularly termed a *fruit.* The rapid development of the fruit draws the sap with increased rapidity towards the branches on which it is situated, so as to cause a speedy exhaustion of the nutritious materials deposited in the stem. Hence the thinning of the fruit of a plant, by increasing the supply afforded to that which is left, insures a greater development in the individuals. Some plants ripen their fruit in a few days after flowering ; most of the grasses take from fifteen days to a month; many, as the Raspberry and Strawberry, take about two months; the Lime and Bird-cherry, three; the Horse-Chestnut and Whitethorn, four; the Apple and Pear, five; the Beech and Walnut, six; the Olive, seven; the Colchicum, eight or nine; most Pines, ten or eleven; but some of them more than a year; and some Oaks require eighteen months. The progress of development of the seed is much accelerated by increase of temperature. The removal of a ring of bark from the branches or stems has a similar effect, by preventing the elaborated juices from descending towards the root.

291. *Action of Fruits upon the Atmosphere.*—According to M. Th. de Saussure, fruits, while green, act much in the same manner as leaves, differing only in the intensity of their action. In the night they absorb the oxygen of the atmosphere, and replace it with carbonic acid, which the partially re-absorb. If exposed to the sun, they disengage, entirely or partially, the oxygen which they inspired at night, and preserve no trace of

carbonic acid in their own atmosphere. Many fruits, on being detached from the plant, thus add oxygen to air, which contains no carbonic acid. When their vegetation is very feeble, or extremely languid, they vitiate the air under all circumstances, but less in the sun than in the shade. Green fruits detached from a plant, and exposed successively to the action of the sun and of darkness, change the air little or not at all, either in purity or volume. In their natural state they decompose, either entirely or in part, not only the c arbonic acid they have produced during the night, but also such quantity as may be artificially added to their atmosphere.

292. *Chemical Changes in the Fruit.*—If we examine the changes which the fleshy parts of fruits undergo in ripening, we first remark that their fibrous or cellular tissue is merely lignin, in most cases lighter and less dense than common lignin, but in the stony parts of fruits denser and heavier. The fluid in succulent pericarps consists of sap lying in the intercellular passages, and the matter contained in the cellules. It contains, besides a great quantity of water, sugar, gum, malic acid, malate of lime, colouring matter, a vegeto-animal substance, and an aromatic secretion peculiar to each fruit, besides several other substances in particular cases. On comparing ripe with unripe fruits, it is found that a large proportion of water has disappeared. This diminution appears to depend partly upon the fruit's absorbing less water as it approaches maturity, and partly upon the combination of a portion of the water it has received with its tissue. Sugar, on the contrary, continually increases as the fruit advances. It is sometimes in a concrete state, as in the Grape and Fig; sometimes liquid; and seems to be formed at the expense of other matters, which are proportionally diminished, gum, jelly, and fecula being very easily convertible into sugar. The other

matters increase in some fruits, and diminish in others. In general, it may be stated, that the solid part of succulent fruits consists of lignin, and their fluid parts of water mixed with gum, malic acid, malate of lime, colouring matter, and vegeto-animal matter, together with an aromatic substance peculiar to each species.

293. *Composition of Ripe Seeds.*—In the progress of development of the seed, the foramen first closes, the embryo makes its appearance in the form of an opaque speck near the summit of the nucleus, gradually projects into the cavity of the ovule, and absorbs the fluid with which it is surrounded, until, when ripe, no water remains in an unfixed state. During its solidification, it exchanges its saccharine matter for the amylaceous, oleaginous, resinous, and other secretions peculiar to it. There is also deposited among its tissue a quantity of earthy matter and of carbon, which gives it a variable degree of hardness, and it is then heavier than water. Complete maturity is not necessary to enable seeds to germinate, as may be seen in corn, which in wet seasons often germinates on the stems; but it seems essential to their preservation for a certain length of time.

294. *Dissemination.*—The manner in which seeds are dispersed varies according to the nature of the plant, and its peculiar conditions. Sometimes, they fall immediately around the parent plant, and spring up, if numerous, to the exclusion of other plants. Many seeds and pericarps are furnished with appendages, by means of which they are transported to a great distance by the winds. Of this kind are the fruits of the Ash and Sycamore, which have wing-like membranes; of the Valerians, which have the calyx developed into filaments; and of the Thistles, Hawkweeds, and other *Compositæ*, which are surmounted by a pappus. Fleshy fruits fall directly to the ground, where they rot, unless eaten or removed by animals.

The seeds of many of them, however, are encased in a hard envelope, which resists the action of moisture, and protects them from the influence of the putrid mass by which they are surrounded. Such fruits are often eaten by animals, which digest the pulp only, the seed being passed by them. Seeds enclosed in capsules are usually dispersed by the wind, which shakes out a few at intervals, but sometimes the valves open with a jerk, and scatter the seeds to a distance. "The various modes," says Sir J. E. Smith, "by which seeds are dispersed cannot fail to strike an observing mind with admiration. Who has not listened in a calm and sunny day to the crackling of furze bushes, caused by the explosion of their little elastic pods; nor watched the down of innumerable seeds floating on the summer breeze, till they are overtaken by a shower, which, moistening their wings, stops their farther flight, and at the same time accomplishes its final purpose by immediately promoting the germination of each seed in the moist earth? How little are children aware, as they blow away the seeds of dandelion, or stick burs in sport upon each other's clothes, that they are fulfilling one of the great ends of nature! Sometimes the *Calyx* (*Involucrum*) beset with hooks, forms a bur, as in *Arctium Lappa;* sometimes hooks encompass the fruit itself, as in *Xanthium*, and some species of *Galium*, particularly *G. Aparine*. Plants thus furnished are observed by Linnæus to thrive best in a rank, manured soil, with which, by being conveyed to the dens of wild animals, they are most likely to meet. The awns of grasses answer the same end. Pulpy fruits serve quadrupeds and birds as food, while their seeds, often small, hard, and indigestible, pass uninjured through the intestines, and are deposited far from their original place of growth, in a condition peculiarly fit for vegetation. Even such seeds as are themselves eaten, like the various

sorts of nuts, are hoarded up in the ground, and occasionally forgotten, or carried to a distance, and in part only devoured. Even the ocean itself serves to waft the larger kinds from their native soil to far distant shores."

295. *Preservation of Seeds and Fruits.* — It appears that the length of time during which seeds can preserve their vegetative powers, depends in a great measure upon the degree of protection afforded them by their integuments; seeds that have a very thick or hard covering, generally retain their vitality much longer than those in which it is soft or membranous. It does not, however, appear that this circumstance alone is that which determines the durability of vitality in seeds, as some not firmly covered, such as those of the *Gramineæ* and *Cruciferæ*, have been known to retain the power of germinating for a long series of years. Seeds of Indian Corn have grown after thirty years, Rye after forty, the Sensitive Plant after sixty, and Kidney Beans, after a hundred years. On turning up ground which has not from time immemorial been under cultivation, many plants are frequently found to spring up, some of them of species different from those growing in the neighbourhood. From observations made on such occasions, and others of a like nature, it is inferred that a uniform temperature, moderate dryness, and exclusion of light, are the conditions most favourable to the preservation of seeds. Various expedients have been tried and suggested for preserving seeds during long voyages, such as putting them into bottles or tin cases, surrounding them with wax or tallow, or burying them in dry clay; but without much success, for most of the seeds of very remote countries seldom survive a protracted voyage, in the course of which they are subjected to great alternations of temperature. The decomposition of fleshy fruits may be prevented for months, by putting them into vessels

hermetically sealed, from which the air has previously been expelled.

296. *Growth and Reproduction of Flowerless Plants.*—In such flowerless plants as resemble in some degree those of the higher classes, we may suppose that the function of assimilation is performed in the same manner as in them. In such other cases as seem to be destitute of the various organs described, the changes subservient to increase in size must take place in the cellular tissue, although in what manner is not apparent. But all these plants differ in being destitute of true seeds, containing reproductive germs, which in becoming developed divide into a descending and an ascending axis. Their sporules, however, are lodged in parts which may be considered as analogous in function to carpels, although they may have no structural resemblance. It is certain that the sporules of Ferns and Mosses act like the seeds of other plants in reproducing individuals of their kind; but they are mere homogeneous masses of matter, and sprout from any point of their surface; that portion which is exposed to the light shooting out into a stem, and that which is in darkness forming a root. But of the peculiarities of the lower tribes, as the Fungi, Lichens, and Algæ, physiologists profess an almost entire ignorance.

Recapitulation.

267. What is meant by Reproduction? By what two modes are plants naturally propagated? What are latent buds? Are plants produced by buds or bulbils in all respects similar to the individuals from which they are derived? 268. How are buds produced? Is a branch emanating from a bud a distinct individual? What is the object of grafting? What other modes of division are there? 269. What is meant by Reproduction properly so called? What organs are subservient to it? Define the seed. Is it a continuation of the

individual, or a new individual? What are the periods of reproduction? 270. At what age do plants flower? In what state are flowers when first distinguishable? 271. What circumstances act as stimuli to flowering? Explain the antagonism which prevails between the reproductive and the nutritive functions. How do you explain the production of double flowers? How is this antagonism exhibited in the Algæ, and in the Fungi? 272. Do plants differ in the period of the year at which they flower? Do individuals of the same species differ in the period of flowering? What advantage of this circumstance is taken by cultivators? How have fruit-trees alternate seasons of productiveness and sterility? 273. What is meant by Flora's Clocks? 274. What are the functions of the perianth? 275. How is fecundation accomplished? Mention some proofs of the existence of sexes in plants. What happens in the case of the Date Palm? How are hybrids produced? 276. Who first brought the existence of sexes into general notice? What exceptions occur to the action of the pollen? May the pollen be transmitted to a great distance? 277. How is the pollen formed? 278. How is the pollen protected from moisture? What contrivances are employed for this purpose in aquatic plants? 279. What happens when the pollen is matured? How is the stigma adapted for receiving the pollen? How is it dispersed? Is rain favourable to fertilization? 280. When the pollen adheres to the stigma, what results? Is there any uniformity as to the number of pollen-tubes emitted from the pollen-grain? What are the views of Amici and of Brongniart as to the action of these tubes? 281. State the three theories of fecundation. What degree of probability attaches to each? 282. Explain Schleiden's views. What remarkable conclusion is derived from them? 283. By what arguments does Meyen oppose the views of Schleiden? What is the germ-vesicle? Of what is it formed? 284. To what is the germ-vesicle indebted for its nourishment? 285. What is the embryo? Whence does the funiculus originate? 286. To what conclusions do the views of Meyen lead? 287. What happens during the period of maturation? 288. Give an

account of the development of the ovules until the period cf the action of the pollen. What is meant by orthotropous, campylotropous, and anatropous ovules? 289. Describe the progress of the seed after impregnation. 290. Give an account of the growth of the pericarp. How does thinning the fruit tend to enlarge it? Do plants vary much with regard to the time occupied in maturing their fruit? What circumstances accelerate maturation? 291. What effect have fruits upon the atmosphere? 292. What chemical changes take place in the fruit? 293. What is the composition of ripe seeds? 294. How are seeds dispersed? 295. Do seeds long retain their vitality? What circumstances are favourable to their preservation? 296. Are the functions of growth and reproduction performed in flowerless plants in the same manner as in others? In what respect are sporules different from seeds?

CHAPTER XXIV.

DIRECTION OF THE ORGANS OF PLANTS.

297. *General Observations.*—We know, as a general fact, that terrestrial bodies tending towards a central point, become aggregated so as to produce an integral mass of matter forming the globe of the earth, and to this general fact we give the name of gravitation; but of the causes and essential nature of gravitation we are ignorant. In like manner, we observe that a plant in germinating shoots a stem upwards into the air, and a root downwards into the ground, and we can perceive the advantages resulting to it from so doing; but we have not discovered the causes by which it is impelled to perform these actions. The phenomena are so common and so obvious, that they scarcely attract notice or excite reflection; yet philosophers have failed to account for them.

Although it is strictly true that stems ascend and roots descend, yet their direction is seldom vertical in the advanced state of the plant. Roots after proceeding downwards, branch out, and run obliquely into the soil, often spreading to a great extent, even farther than the branches; stems are often inclined, sometimes even prostrate; and branches incline in all directions, sometimes even curving downwards.

298. *Effects of Gravitation.*—Various hypotheses have been adduced to account for the direction of the stems and roots; but philosophers have usually, as in other puzzling cases, referred it to the action of the vital principle. It has been supposed by some that gravity is the cause of this phenomenon. Mr. Knight affixed some French beans to the circumference of two wheels, one horizontal, the other vertical, and both kept in constant motion. The radicles of the seed on the vertical wheel extended outwards, the plumules inwards. The seeds on the horizontal wheel sent their radicles downwards, and their plumules upwards; but the radicles inclined outwards, and the plumules inwards, and the more so in proportion to the velocity of the wheel. These modifications of direction were obviously producd by the centrifugal force obviating the effects of gravity; but still this does not account for the natural direction of the radicle. Some had supposed that there is an affinity between the root and moisture or darkness. Dutrochet filled with earth a box, in the bottom of which holes were bored. In those holes he placed French beans, and suspended the box in the air, at the height of about eighteen feet. The seeds thus received from beneath the influence of the atmosphere and light, and the moist earth was placed above them. Were the cause of the direction of the root its predilection for moist earth, the radicle would ascend; but this was not the case, for the roots

shot downwards into the air and soon withered, while the plumules ascended into the soil. It was thus found that there was no affinity between the radicle and the seat of moisture sufficient to counteract its natural downward tendency; and it was also inferred that no more positive affinity existed between the stems and the atmosphere.

299. *Germination of the Mistletoe.*—Parasitic plants, or such as strike their roots into the stems of other plants, seem to be exempt from this general tendency. Thus, the seed of the mistletoe, which is enveloped in a slimy substance, will germinate in any direction, upwards, downwards, or laterally. When it happens to fix itself to the upper part of a branch, its radicle will be directed downwards; but when it is placed on the lower part, the radicle directs itself upwards. M. Dutrochet made it germinate on a cannon ball, when he found that it always directed the radicle toward the centre. Hence, it is obvious, that the tendency of the root of this plant is not towards a medium suited to afford nourishment to the young plant, but that it obeys the attraction of the body on which the seed is fixed, of whatever nature it may be. It is the same with parasitical fungi, and other agamic plants, which do not grow on the ground, but obey the attraction of the bodies to which they adhere.

300. *Effects of Light.*—The radicle of the mistletoe presents another unvarying tendency, that of avoiding light. If seeds of this plant are made to germinate on the inner surface of the pane of a window, all the radicles will be seen turning from the light, and projecting toward the interior of the apartment. If placed on the outside of the glass, their radicles will apply themselves to it, as if tending toward the shade. But the stem of this plant does not show the opposite tendency of directing itself towards the light, for its branches are developed indifferently in all directions. Yet the stems of plants

in general evidently seek the light, as is shown by making them grow in a room, in which light is admitted by a single aperture, in which case they invariably direct themselves to it. This has been supposed to be owing to the greater decomposition of carbonic acid on the side next the light, and a greater deposition of carbon on that side, in consequence of which it acquires a greater rigidity, and the other side having more freedom of development, the stem bends. M. Dutrochet infers from this and other phenomena of a like nature, that light is a principal cause of the direction of the organs of plants; but that those parts only which are green are attracted toward it, while those which are colourless have a contrary tendency, insomuch, that colourless stems are known to assume the direction of roots.

301. *Direction of the Leaves and Flowers.*—The surface of the leaf which is next to the upper part of the plant is always directed toward the sky, and this disposition or tendency is so strong, that, if the position of the leaf be inverted, the petiole will become twisted, so that the leaf will recover its natural position. The upper surface of leaves, in general, is more deeply coloured than the lower; and, as in the case of the stem seeking the light because green, and the root receding from it because pale, it has been said that the upper surface seeks the light, not because it is the upper surface, but because it is of a deeper green. This law is so constant, that, if the surface of a leaf which is naturally inferior is more deeply coloured than the other, the petiole will become twisted, so as to turn it upwards. The same circumstance is observed in the petals, of which the upper surface is generally more highly coloured. But still it is supposed that the direction of the leaves is not mechanically caused by an external agent, but is due to a spontaneous motion, put in action by the influence of external

agency. M. Dutrochet took a leaf, and cutting off its petiole, substituted for it a hair, and sinking it by a weight in a vessel of water, exposed it to the light, the lower surface of the leaf being turned toward the window. No alteration in its position took place, although leaves immersed in water under similar circumstances, but with their petioles and stem uninjured, turned towards the light. In many instances, the direction of the flowers is dependent upon mechanical causes. Thus, when the peduncles are slender and feeble, the flowers necessarily droop, as in many Grasses, the Common Bell-flower, and Hyacinths. But the ultimate cause of the directions assumed by flowers, is probably the protection of the sexual organs during the process of fertilization.

Recapitulation.

297. What is the general direction of the stem? Do roots always descend perpendicularly? 298. What is the cause of this direction? What happened in Mr. Knight's experiment when beans were made to germinate on the circumference of two wheels in motion? Has the root a special predilection for moisture? When Dutrochet caused seeds to germinate in holes in the bottom of a suspended box, what happened? 299. State the peculiarity of the Mistletoe as to germination. Is it the same with any other plants? 300. State the circumstances showing that the radicle of the Mistletoe tends to avoid the light. How is it shown that stems seek the light? How has the curvature of a stem toward the light been accounted for? What is M. Dutrochet's general inference on this subject? 301. If a leaf be inverted, what happens? What side of a leaf is the greener? Why is the upper side directed to the light? Is the direction then entirely caused by light? What happened when a leaf was sunk in water with a hair substituted for its petiole? Why do many flowers droop? What is the probable reason for the directions of flowers?

CHAPTER XXV.

METAMORPHOSIS OF ORGANS.

302. *Regular Metamorphosis.*—It has been assumed, in consequence of an extended comparison of plants with reference to the form, arrangement, and mutual transition of their organs, that all the parts appended to the ascending axis are modifications of a single organ, and may be considered as leaves adapted to special purposes. The organs of plants are disposed, so as to constitute several series of whorls of leaves; and it is found, that in many cases these pass into, or are substituted for, one another.

303. *Leaves, Stipules, and Bracteas.*—The *Leaves,* which have already been pretty fully described, may be assumed as the fundamental organs. Appended to, or connected with them, are the *Stipules.* These organs are not present in all plants. Sometimes they are membranous appendages, destitute of vessels, or having a vascular fasciculus running up their centre. Frequently, as in Roses, and the *Leguminosæ,* they are in pairs, appended to the base of the leaf-stalk, and have a structure similar to that of the divisions of the leaf, although they may differ in form. Sometimes they have the appearance of distinct leaves. They may therefore be considered as rudimentary leaves, or as parts of the leaf. The *Bracteas* are organs intermediate between the leaves and the sepals. In very many plants the leaves, larger and more divided at the base of the axis of vegetation, become gradually smaller and more simple as they ascend on it, and at length, changing their colour and assuming a more

membranous structure, appear as bracteas. Here no real distinction can be made between the leaves and the bracteas. In some Roses the bracteas are exactly similar to the leaves, while in others they are expanded peduncles with enlarged stipules. In the garden Tulip, a bractea is often seen at some distance from the flower, which, in texture and colour, partakes of the nature both of the leaf and the sepal. It has been said that bracteæ differ from leaves, in having no buds in their axillæ; but this is not always the case; for in viviparous plants, such as *Polygonum viviparum*, the flowers themselves are converted into buds in the axils of the bracteæ; *Bellis perennis* sometimes bears buds in the axils of the involucral leaflets; and, in the bracteas of Roses, there is always a bud.

304. *Calyx and Corolla.*—The *Sepals*, as every one must have observed, very often resemble the leaves in structure and colour, sometimes more or less in form. In Roses, one of the sepals is obviously formed like a leaf, and the rest more or less so. The sepals often differ very little from the bracteæ, and in many plants these organs are perfectly identical. It has been objected to this assimilation, that the sepals are always verticillate, or come off at the same level, and that they seldom have buds in their axillæ; but, in order that organs should be considered as modifications of each other, it is not necessary that they should agree in all their characters. Leaves themselves are frequently verticillate in various degrees, and although they should usually be spirally disposed, they might very naturally be supposed to become verticillate when proceeding from the abrupt termination of the axis or branches. In some cases also, as in Double Tulips, the outer leaves or sepals lose their verticillate arrangement; and in double Lilies, all the parts of the flower are disposed alternately upon an

elongated axis. The sepals then are leaves reduced to a particular state.

305. *Corolla and Stamens.*—The corolla is composed of a series of leaves, alternating with those of the calyx, and not always distinguishable from them. In many plants the sepals and petals are alike in colour, texture, and odour; and when the perianth is single, the sepals and petals seem to be combined. The stamens, when in a single row, alternate with the petals; or, if opposite to them, may be considered as belonging to a second or inner row. The expansions of the filaments sometimes form petaloid bodies, as in the cup of Narcissus, which, from analogy, is considered as formed of the three outer stamens expanded and united. In the White Water-Lily, the petals gradually diminish in size toward the axis, their margins become altered and assume a yellow colour, and the transition proceeds until we come to the regularly formed stamens. A similar transition is observed in Double Roses, Anemonies, Ranunculuses, Cherries, and Almonds.

306. *The Carpels.*—In its most simple state, the Carpel bears the greatest analogy to a leaf, as is seen in the pod of the pea, which resembles a leaf folded upon itself. The same structure is seen in many fruits, of which the carpels are arranged in a verticil, and from the various modifications thus produced are derived the varieties of form and internal division of the ovarium, which have already been described, § 167, p. 105. Sometimes the pistil reverts to the state of a green leaf, folded upon itself, as in the double Cherry. Frequently also it reverts to the state of petals, as in double Narcissi, Wall-flowers, Ranunculuses, and Saxifrages. It is remarkable, however, that the pistil seldom reverts to the form of the stamen, and that transitions between the stamens and pistils are very rarely met with.

From what has been said above, it appears that all the organs of Flowering Plants are similar in their general plan, graduate into each other, and may be considered as leaves modified for special purposes. The subject is what some have named *Morphology*, and refers to the natural or normal condition of the organs.

307. *Irregular Metamorphosis.* — Owing to various circumstances, especially superabundant nourishment, change of soil and climate, and the alteration of the natural condition of plants, they undergo many changes in all their organs. It is probable that every plant has a particular range of distribution, in which, being subjected to limited atmospherical influences, it remains unchanged; but that, when its conditions are materially altered, its form and functions are liable to be modified. In the wild or natural state changes of this kind are rare, while in our gardens and hot-houses they are continually taking place. Of the essential causes of these changes, and the precise manner in which they are effected, it appears that nothing is known with certainty.

308. *Changes of Roots and Tubers.* — The roots of plants undergo numberless changes. Thus, the wild carrot has a slender tapering fleshy root of a yellowish white colour; in sandy soil denser, more tinged with yellow, and having an aromatic flavour; in rich soil, more succulent, whiter, and sweetish. Under cultivation, it increases, becomes much more fleshy, and assumes a deep orange or red colour. The Parsnip varies from fusiform to conical; the Turnip from globular to depressed, turbinate, and fusiform, the epidermis being white, yellow, purple, or partially green. The Potato assumes numberless shapes, being orbicular, oblong, flattened, or curved; and various colours, as white, yellow, red, purple, or variegated; even its interior becoming sometimes purple or blackish.

309. *The Stem and Leaves.*—Changes of the stem are less frequent. In alpine situations the stem becomes short, and in low and humid situations elongated; in open pastures firm and coloured, in woods more tender and green. By domestication tall stems are rendered short, and short stems lengthened. The stem of the Wild Cabbage is rather firm and slender, but in a cultivated variety it has become fleshy and fusiform, and in another forms a fleshy tumour above the ground. The changes which leaves undergo are numberless. In some varieties of the Cabbage and Lettuce, for example, they enlarge, become more succulent, and curve inwards, forming what gardeners call a heart. In other varieties, the parenchyma increases more than the veins, and they become puckered; and again, the margins enlarge more than the disk, when they become curled. Simple leaves assume various marginal alterations, or even become compound; and compound leaves are sometimes rendered simple, or lose some of their parts, or acquire additional parts. The colours of leaves also undergo many changes.

310.—*Changes of Flowers.*—Changes in the floral organs are extremely common. The petals are increased in number, stamens are converted into petals, the colours of the parts are altered, and their odours modified. The sepals of the tulip, which are six, are multiplied indefinitely, and assume numberless tints and patterns. Roses, Anemonies, and Ranunculuses, which in the natural state have five petals, acquire an indefinite number. When the petals are increased by an additional whorl or two, the flower is said to be *double;* but when the increase is so great, as to destroy the sexual organs, it is said to be *full.* "With regard to colour," as Professor Lindley observes, "its infinite changes and metamorphoses in almost every cultivated flower, can be compared to nothing but the alterations caused in the plumage

of birds, or the hairs of animals by domestication. No cause has ever been assigned for these phenomena, nor has any attempt been made to determine the cause in plants. We are, however, in possession of the knowledge of some of the laws under which change of colour is effected. A blue flower will change to white or red, but not to bright yellow; a bright yellow flower will become white or red, but never blue. Thus, the hyacinth, of which the primitive colour is blue, produces abundance of white and red varieties, but nothing that can be compared to bright yellow; the yellow hyacinths, as they are called, being a sort of pale yellow ochre verging to green. Again, the ranunculus, which is originally of an intense yellow, sports into scarlet, red, purple, and almost any colour but blue. White flowers, which have a tendency to produce red, will never sport to blue, although they will to yellow; the Roses, for example, and Crysanthemums."

311. *Changes in the Fruit.*—These are very common and obvious. The Crab Apple, a small, globular, acid fruit, has, by cultivation, been converted into numberless varieties, differing in size, colour, flavour, and smell. The Sloe, in like manner, has produced the different kinds of plum. The varieties of the Bean and the Pea, and in short of almost all the Plants cultivated for their fruits, or seeds, are endless. In herbaceous plants, these varieties may be propagated by the seeds, but in trees only by subdivision, that is by grafting, by slips, suckers, or layers.

Recapitulation.

302. Do the organs of plants graduate into each other? 303. Have all plants stipules? What appearance do the stipules present? Why may they be considered as rudimentary leaves, or as parts of the leaf? How do leaves graduate

into bracteas? What takes place in Roses and Tulips? Have bracteæ axillar buds? 304. Do sepals ever resemble leaves or bracteas? How do they differ from leaves as to arrangement? Are leaves ever verticillate? Are sepals always so? 305. Of what is the corolla composed? Are the sepals and petals ever similar on the same plants? Do the stamens ever assume the appearance of petals? Mention an instance of the gradation of petals into stamens. 306. How is a carpel analogous to a leaf? Mention an instance of the pistil becoming a leaf. In what plants does the pistil revert to the state of petals? What is Morphology? 307. What is meant by Irregular Metamorphosis? How are changes produced in plants? 308. Mention some instances of changes in the root. 309. What changes take place in the stem? Are the leaves very liable to change? What is called a heart? How are curled leaves produced? 310. What changes take place in flowers? What are Double and Full flowers? Do all colours change into each other? 311. From what plants are the cultivated apples and plums derived?

CHAPTER XXVI.

REMARKS ON THE GEOGRAPHICAL DISTRIBUTION OF PLANTS.

312. *General Remarks.*—Botanical Geography, which includes the distribution of plants over the globe, the relative number of families, genera, and species, in different districts, the influence of heat, altitude of situation, and soil, the means of dispersion and limitation, together with various subordinate subjects, cannot be here spoken of in full, because a knowledge of the specific forms of plants, and their arrangement into groups, is necessary to him who would enter upon its consideration. But some observations on this important subject may

here be made with advantage to the student. If we examine our own country with reference to its vegetation, we find, that many of the plants which occur on the sea-shore are different from those met with in the interior, and that the summits of mountains exceeding 3000 feet in height have a vegetation unlike that of the plains and valleys. Were we to extend our view to other countries, we should find, that although most of the plants of Britain occur in France, while those of the latter country re-appear in Spain, yet that many species are peculiar to each of these regions; and that countries very distant from each other, as Otaheite and Spitzbergen, have few or no plants in common.

313. *Stations of Plants.* — The situations in which plants naturally thrive best, considered as to elevation, the nature of the soil, proximity to the sea or to the snow-line, and other circumstances of a like nature, are termed *Stations*. Of these the following are the most definite :—

1. *The Sea.* Many plants live immersed in salt water, or float on its surface. Of this kind are most of those forming the family of *Algæ*. They are accordingly termed *Marine Plants*.

2. *The Sea-shore.* Others reside on the borders of the sea, and thrive only when exposed to the influence of the spray and sea-breezes. Of this kind are the *Salicorniæ*, *Glaux maritima*, and *Arenaria peploides*. It is very remarkable, that several plants which grow near the sea occur on the summits of high mountains; as *Statice Armeria*, *Plantago maritima*, and *Rhodiola rosea*. Plants whose station is the sea-shore are named *Maritime*.

3. *Fresh water.* Some plants live in fresh water, entirely submersed, as *Confervæ;* floating loose on the surface, as *Stratiotes;* rooted in the mud, with the leaves and flowers floating, as *Nymphæa;* or similarly rooted,

but with these organs rising above the surface, as *Alisma Plantago.* Such plants are *Aquatic.* They are also named *Lacustrine* when growing in lakes, and *Fluviatile* when in rivers.

4. *Marshes.* Hollow or low grounds partially covered with water, or entirely covered to a small depth, or covered in one season and dry at another, as well as the wet margins of lakes and rivers, ditches, and wet meadows, produce certain plants, as *Menyanthes trifoliata, Caltha palustris, Galium uliginosum.* Such are termed *Palustrine.*

5. *Pastures. Meadows,* or moist grassy places ; and *Pastures,* or dry grounds covered with grass. *Cardamine pratensis, Poa pratensis, Senecio Jacobæa. Meadow* and *Pasture Plants. Pratensine.*

6. *Cultivated Lands.* Together with pasture plants, this kind of ground produces species introduced by the agency of man. *Stellaria media, Spergula arvensis, Agrostemma Githago. Arvensine.*

7. *Rocks.* Many cryptogamic plants abound on rocks, and a few others prefer them. Old buildings and walls rank with rocks in this respect. *Saxifraga hypnoides, Cheiranthus Cheiri. Rupestrine, Murine.*

8. *Sands, Sandy or Gravelly Soil.* This kind of station ought to refer to the interior exclusively, but is not definite. *Arenaria serpyllifolia. Arenaceous Plants.*

9. *Rubbish.* Places in the vicinity of dwellings nourish plants, such as the Nettle, which seem to follow man. *Ruderal.*

10. *Woods.* Forests and woods of tall trees. The plants growing in this kind of station are the trees themselves, and the herbaceous plants which thrive in their shade. *Sylvan.*

11. *Copses.* Thickets, hedges, and bushy places. Shrubs and herbaceous plants. *Dumose.*

12. *Mountains.* Hills and mountains produce numerous plants not found in valleys or plains. This head includes upland pastures, mountainous situations, and alpine stations, the latter being those near the line of perpetual snow. *Colline, Montose, Alpine.*

13. *Caves.* Dark places underground, such as caves, mines, wells, and the like, produce some peculiar plants, which may be called *Subterranean.*

14. *Plants.* Many plants grow on others, whether living or dead, without deriving nourishment from them, and are named *Epiphyte;* while others, adhering to the surface of plants, extract nourishment from them, and are said to be *Parasitic.*

314. *Habitations of Plants.*—The particular kind of situation in which a plant occurs—for example, the sea-shore—differs from what is technically called its *Habitation.* This latter term is applied to the range of growth of a species, or the extent of the earth's surface, on which it is found in a natural state. It is a remarkable circumstance, that most plants are restricted, not only in longitude, which they might readily be supposed to be from the effects of temperature alone, but also in latitude. Plants of particular species, therefore, do not form transverse belts on the earth's surface, but are distributed in irregular patches. Perhaps no plants are of general distribution ; but some have an extensive range, and are found in both hemispheres. But the greater number are restricted within moderate, and many within narrow, limits. It is thus probable that plants have not emanated from original individuals placed in a central district, or in several centres of vegetation, but have been derived from individuals placed originally in particular spots, from which their offspring have radiated until their migrations have been stopped by seas, deserts, mountain-ridges, and similar obstacles.

315. *Circumstances facilitating Migration.*—The dispersion of plants appears to take place chiefly by means of the atmosphere. As has already been stated, § 294, the seeds of many plants are so small and light that they are easily transported by the winds; while others are furnished with wings or crowns, which render them lighter by increasing their surface, or they are surmounted by tufts, the filaments of which, on separating, serve as levers, to enable them to issue from the pericarp or involucre, and afterwards support them in the air. The minute sporules of cryptogamic plants especially, appear capable of being transported to considerable distances in this manner. Rivers are also a probable means of dispersing seeds, and are known occasionally to carry entire plants from the mountainous regions to the plains. The sea occasionally serves the same purpose in warm climates, but its effects have been greatly overrated. Seeds frequently become entangled in the wool and hair of animals, and may be carried to some distance, while others pass through their alimentary canal uninjured, and may spring up in places remote from that of the parent plant. Man, however, has done more for the dispersion of plants than all the other animals. Some are accidentally transported by him wherever he extends his migrations, and many have been purposely carried by him to all parts of the globe.

316. *Obstacles to Migration.*—The ocean presents an obstacle to the migration of plants proportionate to its extent; for, as salt water is found to destroy the vitality of seeds long subjected to its influence, there is less chance of an interchange of species between lands situated at great distances from each other than between those which are near. Regions covered with arid sand, such as occur on the African continent, may also be supposed to present effectual barriers to the extension of vegeta-

tion; and thus the plants of the western are different from those of the northern and eastern parts of that continent. Elevated mountain-ridges, especially when they rise into the region of perennial snow, have a similar, but less remarkable effect; for, although the cold of their summits may form a sufficient obstacle, they are intersected by ravines and transverse valleys, by which migration may take place. Other circumstances might be mentioned, as forming obstacles to the dispersion of plants; but the circumstances which have the greatest influence upon it are light, heat, moisture, and the nature of the soil.

317. *Influence of Soil.*—The chemical nature of the materials of which the soil is composed, appears to have very little influence upon the kind of vegetation which it produces. The same species are found to grow in soil of which carbonate of lime is a principal ingredient, and in that composed chiefly of alumina or magnesian earth; and maritime plants grow in calcareous as well as in silicious sand; while alpine species are found on granitic as well as on schistose summits. It is therefore probable, that the degree of disintegration of the materials of which soils are composed, and their capability of retaining moisture, are the circumstances on which their adaptation for particular plants chiefly depends. The degree in which water is retained in the soil is generally proportionate to the quantity of alumina in it; and those soils which contain silicious matter in a state of comminution, most readily give out their moisture.

318. *Influence of Moisture.*—The different stations of plants above enumerated are differently supplied with moisture; and different species of plants are differently constituted in this respect. But, beyond a few superficial generalizations, it does not appear that much is known on this subject. The greater the supply of mois-

ture, combined with a proportional heat, the greater is the development of vegetation; and while the arid wastes of Africa scarcely produce any plants, the borders of springs or pools which occur on them are furnished with palms and other plants, which flourish luxuriantly. While the great plains of South America are, during the seasons of drought, converted into regions of sterility, no sooner have the periodical rains fallen than they present an ocean of verdure.

319. *Influence of Heat.*—As we proceed from the equator towards the pole, we find that the vegetation gradually decreases in vigour; and, as we ascend from the sea-shore towards the summits of lofty mountains, we observe a repetition of the same circumstance; until at last, having come to the limits of perennial snow and ice, we find a total cessation of vegetative power. Various forms of vegetation present themselves in different regions; and, in passing from the equator to the pole, we traverse a succession of regions characterized by peculiar plants, insomuch that, although two contiguous regions may not differ very remarkably, the extremes of the series may have no plants in common. As the temperature diminishes in proportion as we ascend a mountain-chain, the vegetation presents itself in belts or zones, certain species being confined within certain limits as to height. But the zones of vegetation observed from the equator to the pole are undefined and interrupted, the species being of varied extent, both as to longitude and latitude. The mean annual temperature, differences in the same latitudes between the heat of summer and winter, and other circumstances, give rise to these irregularities, the consideration of which requires a previous knowledge of the families of vegetables, as well as of other subjects not properly belonging to those treated of in this volume.

Recapitulation.

312. What is meant by Botanical Geography? 313. Describe the different stations of plants. 314. What is meant by Habitation? 315. What circumstances facilitate Migration of plants? 316. What are the principal obstacles to the migration of plants? Has salt water an injurious effect upon seeds? How do deserts prevent the dispersion of plants? Do mountain-chains present equally insurmountable barriers? 317. Has the chemical nature of the soil much influence on the distribution of plants? On what circumstances does the adaptation of soils for particular plants chiefly depend? What soils are most retentive of moisture? 318. What effect does moisture produce on the vegetation of the deserts of Africa, and the plains of South America? 319. What is observed with regard to the vegetation in proceeding from the equator to the pole, and from the sea-level to the summits of mountains?

CHAPTER XXVII.

SPECIES, VARIETIES, AND HYBRIDS.

320. *General Idea of Species.*—Although the idea of a *Species*, or particular kind of plant or animal, is familiar, and generally understood, it is difficult strictly to define the limits of each species, or to form a correct general idea of what is meant by the term. A Lion, a Tiger, an Elephant, a Horse, and a Man, are individuals representing so many species. The particular lion referred to, and all the other lions in the world, constitute the species to which we give the general name of lion; and so of the others. But, if we examine all the lions in the world, or as many of them as we can find, we may

be induced to conceive that there may be several species of Lions; for example, the Asiatic Lion, the Barbary Lion, and the Senegal Lion. So also there may be several species of Elephant; and in fact, we know two, the Asiatic and the African. Now, if these two Elephants, which differ in characters not remarkably obvious, are yet distinct, are we to consider all such characters always indicative of distinct species? The Bull-dog, the Shepherd's Dog, and the Greyhound, differ very considerably from each other. Are they distinct species, or merely varieties of one species? It is pretty generally agreed, that individual animals which breed together, and produce a fertile progeny, are of the same species. If this opinion be correct, all the domestic dogs are merely varieties of a single species; the European Man, the Negro, the Malay, the Tartar, and the New Hollander, belong to one and the same species. It is the same among plants. If among them we define a species to be—the aggregate of individuals agreeing in all their essential characters, breeding freely together, and producing perfect seed, which gives rise to similar individuals, also breeding together—we may be correct, but our definition is vague, and not applicable in practice, for it is only in very few cases that we can determine species by it. There is nothing absolutely certain as to species, much less as to the groups into which they are disposed, as genera, families, orders, tribes, and the like. We merely agree to consider as species individual plants which closely resemble each other in the structure and form of their organs. Such species, however, often pass into each other by gradations, which render it impossible to draw a line of demarcation, and thus all species are more or less arbitrary. We know from observation, that all assumed species undergo changes from climate, cultivation, and other influences; and individuals exhibiting

remarkable alterations we call collectively varieties; but variety is a still more vague idea than species.

321. *Varieties.*—If we assume that a few individual plants, precisely similar in all respects, and differing in some respects from all others, were originally created, we should call these plants and their progeny, up to the present day, a species. Or a single original plant and its offspring would be a species. From various causes, individuals that have been derived from these original individuals may differ considerably from them, and yet be of the same species. Supposing a plant to have been originally, or many individuals of its offspring to be at present, three feet high, with an erect stem, cordate downy leaves, and blue flowers, one or many individuals of the same may be much smaller, with decumbent stem, oblong hairy leaves, and white flowers, although in other more important characters they might agree; such changed individuals would form a *Variety.* While species, having the normal form and colours, are perpetuated by seed, varieties, although often also propagated in the same manner, are liable to return to the original form, or to deviate into others; and accidental varieties, originating in cultivation, must be propagated, if it be desirable to preserve them, by grafting, or by slips, or such other means. All species have a tendency to form varieties, insomuch, that no two individuals are ever precisely alike in all respects. The general idea of a variety is thus as vague as that of a species; and the only correct idea of species would be that which should include every character or feature common to all the individuals composing it. But our idea of species is derived from the form of the organs merely. In practice, however, we contrive to distinguish species sufficiently for many useful purposes.

322. *Hybrids.*—Among wild animals, individuals of a species usually have so much aversion from indivi-

duals of another species, that instances of sexual union are extremely rare. Among plants in the same state, although not having instincts and propensities like animals, an intermixture of species is also of very rare occurrence. This probably arises from impregnation having been effected before the pollen from another plant can reach the stigma. But, in a state of cultivation hybridism sometimes occurs, and may readily be induced by art. It is only plants of the same genus, or, at most, of very nearly allied genera, that intermingle in this manner. Even species of the same genus, if very different in appearance, cannot be made to produce hybrids. If the anthers of a plant be removed before bursting, and the pollen of another species of the same genus be applied to its stigma, there will be produced seed, which will give rise to individuals having characters partaking of the nature of both parents. The individuals thus produced are capable of performing all the functions of their parents, but they cannot produce seed capable of giving rise to individuals similar to themselves; for sometimes they are sterile, or become so in a few generations, or the individuals produced by them tend to return to the form of one or other of the parents, and if a hybrid individual be artificially impregnated with the pollen of one or other of the species from which it has originated, it will return to the form of that species. It is possible that some supposed species may be mere hybrids, as in the genus *Rosa* and *Rubus;* but it seems more probable that, if not species, they are rather varieties than hybrids. There are, however, various instances of hybridism, even in the wild state; but this accident or circumstance appears to have little general effect in modifying the vegetation of the globe. Although we have no certain data from which we can infer the general permanence of specific forms, yet the considerable number of plants, or parts of plants,

found in the catacombs of Egypt, show that the species to which they belong have continued unaltered for more than 3000 years.

323. *Experiments in Hybridism.*—In 1775, Kölreuter performed some accurate experiments on this subject. He obtained a hybrid from two species of tobacco—the *Nicotiana rustica*, and the *N. paniculata*—which differ greatly in the shape of their leaves, the colour of the corolla, and the height of the stem. The seed ripened, and produced a hybrid, which was intermediate in its characters between the two parents, and which, like all the hybrids reared by this botanist, had imperfect stamens. He afterwards impregnated this hybrid with the pollen of *N. paniculata*, and obtained plants much more resembling the last. This process he continued through several generations, until, by due perseverance, he actually changed the *N. rustica* into the *N. paniculata*. His plan of impregnation consisted in cutting off the anthers of the plant intended for fructification, before they had shed their pollen, and then laying foreign pollen on the stigma. This experiment has since been repeated by Wiegmann, who found that he could bring back the hybrids to the exact likeness of either parent, by crossing them a sufficient number of times. This botanist observes that vegetable hybrids, when not strictly intermediate, more frequently approach the female than the male species, but *they never exhibit characters foreign to both.*

Recapitulation.

320. Is it difficult to define species? What is the cause of the difficulty? What is a species of plants? Do assumed species often pass into each other? 321. What is meant by a Variety? Are varieties propagated by seed? 322. What is a Hybrid? Why are hybrids rare in the wild state? How

may they be artificially produced? Will any two species of plants produce hybrids? May hybrids be perpetuated by their seeds? Are there any reasons for supposing that specific forms are permanent? 323. Describe the experiment performed by Kölreuter.

CHAPTER XXVIII.

DISEASES, DURATION, DECAY, AND DECOMPOSITION OF VEGETABLES.

324. *Diseases of Plants.*—Like animals, plants are subject to deviations from the healthy condition of their organization, but their diseases are less numerous, less complicated, and it may be added, less known. It will suffice here to mention some of the most common forms of disease.

1. *Blanching.*—A kind of constitutional feebleness, indicated by elongation and slenderness of the stem and branches, incapability of producing, or at least of perfecting flowers, and a general paleness of the green parts. Moisture, combined with cold, and little sunshine, may be the cause of this disease.

2. *Gangrene.*—A general languor of the system, flaccidity of the leaves, and decomposition of them and the twigs; probably arising from excessive cold, and subsequent rapid change to heat. The disease may be general or local.

3. *Canker.*—According to Professor Lindley, this affection "exhibits itself internally in a brown discolouration of the medulla and parts adjacent, and externally in small brown dead spots, which gradually extend on all sides, until they surround the branch, and kill it. These

spots are always dry and hard, never containing any fluid. It is this which is so fatal to many of the apple and pear trees of this country. Its cause and mode of cure are equally unknown. Apparently, healthy shoots will, if grafted on another stock, carry the disease with them."

4. *Carcinoma.*—As defined by the same author, this "is a disease in which an unusual deposit of cambium takes place between the wood and the bark; no wood is formed, but instead, the cambium becomes putrid, and oozes out through the bark, which thus separates from the alburnum."

5. *Spotting.*—The appearance of small black spots on the leaves and parenchymatous parts of plants, with decay of the subjacent substance.

6. *Gumming.*—A discharge of thick sap through the bark, with drying of the surrounding parts.

7. *Excrescences.*—By the puncture of insects, excrescences of various kinds are produced on the leaves and stems of plants, sometimes the calyx, germen, or other parts. The irritation caused by the egg, or by the larva, of the insect, causes a deposition of parenchymatous tissue, which assumes various forms, but does not affect the general health of the plant, or even that of the neighbouring parts. Gall-nuts are produced in this manner.

8. *Smut and Rust.*—A conversion of the seed or other part of a plant into a granular substance, of a brown, black, red, or yellow colour.

9. *Ergot.* — An enlargement and elongation of the seeds of grasses, which assume a brown or blackish colour, and contain a powdery, somewhat unctuous substance, producing very deleterious effects on animals which feed on grain intermixed with it.

Many other diseases, distinguished by fanciful names, and bearing little analogy to the diseases of animals similarly named, might be mentioned. Thus *Hypertrophy*

is an enlargement of a part, or organ; *Pernio*, a wound or ulcer caused by frost; *Exostosis*, a "clubbing of the roots." Besides, plants are liable to external injuries of various kinds: *Wounds, lopping, fracture, constriction* by climbing plants, *erosion* by animals, and the like.

325. *Duration of Plants.*—Some species of vegetables exist only a few days, a few weeks, or a few months, and are named annual plants. Other species, which spring up in autumn, survive the winter, produce flowers in summer, perfect their seeds and die in autumn, are named Biennial. Plants of these kinds produce seeds only once in their lives, and so are said to be *Monocarpean.* Others which last several years, produce fruit more than once, and thus obtain the title of *Polycarpean.* Of these some last only a few years, while others extend their duration over a long series of years, and many endure for centuries, nay, even thousands of years. These long-living plants are all ligneous, and belong to both divisions of the Embryonate series.

326. *Longevity of Trees.*—The age of dicotyledonous trees may be satisfactorily ascertained by counting the number of woody layers in a transverse section. But an approximation may be made even in a living tree. The rate at which trees of a particular species increase in diameter, within known intervals, may be determined by measuring the radius, or the diameter, of sections of different individuals, and thus finding the average annual increase. The diameter of a growing tree being ascertained, its age may be guessed at by referring to the known rate of increase of the species. Thus, M. De Candolle having ascertained that three yew trees, which were felled, had grown at the rate of a twelfth of an inch in diameter annually for a hundred and fifty years, and that one of them had increased somewhat less rapidly during the next century, applied the rate of growth thus

obtained to some English yews described by Evelyn and Pennant, one of which, mentioned by the former as growing in Braburn in Kent, in 1666, was fifty-eight feet nine inches in circumference, or 2820 lines in diameter, and therefore as many years old. But this method is liable to objections, inasmuch as trees do not increase uniformly in diameter, some layers being much thicker than others, and trees grow more rapidly in their first years than afterwards. Adanson found that some Baobab trees in Senegal had increased two feet in diameter in two centuries, so that individuals thirty feet in diameter would be 3000 years old. But, by ascertaining the height and diameter of young trees of various ages, he came to the conclusion, that a tree twenty feet in diameter would be 2800 years old, and one thirty feet, 5150 years. But, if these and other methods of estimating the age of trees are not entirely to be depended upon, there can be little doubt that many individuals now living are some thousands of years old, and that some may even be coeval with the human race.

327. *Fall of the Leaf.*—Plants having, for a period peculiar to each species, lived, vegetated, and fructified, begin to decay. Even early, in the perennial species, there is a decay of some of the organs. In some, the whole plant dies down to the roots ; in others, the leaves only fall off. The fall of the leaf in autumn has been variously accounted for. It is observed, that in general, the trees whose leaves are earliest expanded are those which lose them first, as is the case with the Lime, Birch, and Plane. The Ash is an exception, its leaves being very late in expanding, and early in falling. Petiolate leaves, and especially those which are articulated upon the stem, are sooner detached than those which are sessile or amplexicaul. In herbaceous plants, the leaves generally decay along with the stem, without falling.

Although the fall of the leaves usually takes place at the approach of winter, cold is not the cause of the phenomenon, but rather the interruption to the course of the sap, when vegetation ceases, the vessels of the leaf becoming dried up.

328. *Decay of Plants.*—On this subject Dr. Thomson of Glasgow has the following remarks:—"As long as a plant continues to vegetate, we say it lives; when it ceases to vegetate, we conclude that it is dead. The life of vegetables, however, is not so intimately connected with the phenomena of vegetation, that they cannot be separated. Many seeds may be kept for years without giving any symptom of vegetation; yet, if they vegetate when put into the earth, we say that they possess life; and, if we would speak accurately, we must say also that they possessed life even before they were put into the earth: for it would be absurd to suppose that the seed obtained life merely by being put into the earth. In like manner, many plants decay, and give no symptoms of vegetation during winter; yet, if they vegetate when the mild temperature of spring affects them, we consider them as having lived all winter. The life of plants, then, and the phenomena of vegetation, are not precisely the same thing; for the one may be separated from the other, and we can even suppose the one to exist without the other. Nay, what is more, we can in many cases decide, without hesitation, that a vegetable is not dead, even when no vegetation appears; and the proof which we have for its life is, that it remains unaltered; for, we know, that when a vegetable is dead, it soon changes its appearance, and falls into decay. Thus, it appears, that the life of a vegetable consists in two things: 1. In remaining unaltered, when circumstances are unfavourable to vegetation; 2. In exhibiting the phenomena of vegetation, when circumstances are favourable. When neither of

these two things happens, we may say that a vegetable is dead." These remarks, however, throw no light upon the essential nature of vegetable life, which, it is to be apprehended, we must be content to be ignorant of. "The death of plants, if we can judge from the phenomena, is owing to the organs becoming at last altogether unfit for performing their functions, and incapable of being repaired by any of the powers which the vegetative principle possesses.

329. *Decomposition of Vegetables.*—"The most striking distinction," Dr. Thomson remarks, "between the substances belonging to the mineral kingdom, and those which make a part of animals or vegetables, is, that mineral bodies show little or no tendency to change their nature, and when left to themselves, undergo no spontaneous decompositions; whereas animal and vegetable substances are continually altering, and, when left to themselves in favourable circumstances, always run through a regular set of decompositions." During vegetation the constituents of plants are continually changing, and becoming converted into other substances; after the death of the plant, this tendency to change exhibits still greater energy. In the spontaneous decomposition of vegetables the specific gravity of the new compounds formed, is almost always less than that of the old body. Some of them usually fly off in the state of gas or vapour, whence the odour emitted by vegetable bodies during the whole time of their decomposition. When this odour is very offensive, the decomposition is called *putrefaction;* when not offensive, it is called *fermentation;* but the latter term is applied by some to all the stages or degrees of decomposition in vegetables.

330. *Fermentation.*—Dead vegetable substances containing water, and exposed to a moderate or high temperature, undergo fermentation. Some vegetable prin-

ciples, as gum, starch, wax, resin, and lignin, though mixed with water, and placed in the most favourable temperature, show little tendency to change their nature; whereas albumen and fibrine putrify very rapidly. It is when several of the vegetable principles are mixed together that the fermentation is most remarkable. When gluten is added to a solution of sugar in water, the liquid soon runs into vinegar, or, in certain cases, to alcohol and vinegar. When gluten is mixed with starch and water, alcohol and vinegar usually make their appearance; but the greatest part of the starch remains unaltered. Certain substances also called *Ferments*, are peculiarly efficacious in exciting fermentation in others. The liquid parts of plants, such as the sap of trees, the juices of fruits, and the decoctions of seeds, roots, or leaves, are those which exhibit this phenomenon in the greatest activity. Three kinds of fermentation are distinguished—the Vinous, Panary, and Acetous. Under the name of *Vinous Fermentation* is included every kind which terminates in the formation of intoxicating liquids. These liquids may be comprehended under two general heads; those obtained from the decoction of seeds, and those obtained from the juices of plants. The liquids of the first class are denominated Beer or Wash, those of the second Wine.

331. *Vinous and Acetous Fermentations.*—The farinaceous seeds of plants being steeped for some time in cold water, are removed from it, and placed in a heap, which after some time is stirred, and then spread out. The seeds, when in the heap, absorb oxygen from the atmosphere, and convert it into carbonic acid; the temperature gradually rises, and the seeds, which had become dry on the surface, become again moist, and exhale an agreeable odour. Germination takes place to a certain extent, and the kernels undergo a change, their glutinous

and mucilaginous matter being removed, and the texture rendered loose and friable. The seeds are now dried by artificial heat, and ground in a mill. The *Malt* thus formed is infused in water at a high temperature, and the liquid obtained is called *Wort.* This liquid consists of water holding the farinaceous part of the seeds in solution, and is formed of saccharine matter, starch, mucilage, and some other substances. When sufficiently concentrated by boiling, the wort is put into flat vessels in an open situation, cooled, and then let into deep vessels where, at a favourable temperature, it ferments, the temperature rises, an internal motion takes place, and carbonic acid gas is emitted. By adding a peculiar substance named yeast, of which the essential element appears to be gluten, the temperature rises, carbonic acid is disengaged, and the saccharine matter is converted into alcohol. The sweet liquor obtained from grapes, apples, gooseberries, currants, and the like, is named *Must,* and that from grapes is composed of water, sugar, jelly, gluten, and tartaric acid. When must is put into a moderately high temperature it ferments, acquires a higher temperature, and emits carbonic acid. In a few days the fermentation ceases, the liquid becomes clear, it has lost its sweet taste, has a less specific gravity, and is known by the name of *Wine.* This liquid consists of water, alcohol, an acid, extractive matter, and colouring matter. The Acetous Fermentation takes place as follows:—Wine or beer kept at a moderately high temperature, with access to the air, gradually becomes thick, acquires a higher temperature, is agitated by an internal motion, and emits a hissing noise. Gradually its motion ceases, filaments attach themselves to the sides and bottom of the vessel, and the liquor, having become clear, is found to be *Acetous Acid,* or vinegar.

332. *Putrefaction.*—Vegetable substances exposed to

the air at a moderate temperature, with access to moisture, putrefy, or are decomposed, emitting a disagreeable smell. When moist vegetable matter is accumulated during hot weather, oxygen gas is absorbed and converted into carbonic acid, while the temperature augments, and combustion sometimes takes place. Hay, straw, cotton, and other vegetable matters, have frequently been consumed in this manner. When vegetable matters are composed of carbon, hydrogen, and oxygen only, the smell which they emit is not very offensive; but when azote is present, as in the *Cruciferæ*, they give out a very disagreeable odour; and still more so, when they also contain sulphur and phosphorus. Lastly, when vegetable bodies putrefy on the surface of the ground, they at last leave a blackish brown powder, to which the name of *Vegetable Soil*, or *Humus*, is given. This substance, mixing with the soil, and gradually accumulating, is supposed to be subservient to the nourishment of future vegetables.

Recapitulation.

324. Are plants liable to numerous diseases? What is Blanching? Gangrene? Canker? Carcinoma? Spotting? What effect is produced by the puncture of insects? What are Smut and Rust? Define Ergot. 325. Do plants differ much in their duration? What are Monocarpean and Polycarpean Plants? 326. How is the age of Dicotyledonous Plants determined? In what manner may an approximation be made to the age of a growing tree? What age was attributed by Adanson to a Baobab thirty feet in diameter. 327. Give some account of the Fall of the Leaf. To what is it owing? 328. Is vegetation the criterion of life? When vegetation has ceased, or been intermitted, how may we judge that the plant yet lives? In what two things does the life of a plant appear to consist? To what is the death of plants

owing? 329. What difference exists between minerals and organized bodies as to decomposition? 330. Do vegetable substances vary in the facility with which they decompose? When gluten is added to a solution of sugar in water, what follows? What are Ferments? What is Fermentation? How many kinds of Fermentation are there? 331. Give an account of the Vinous Fermentation, first, in the decoction of the farinaceous seeds of plants; secondly, in the juices of fruits. What takes place in Acetous Fermentation? 332. What is Putrefaction, properly so called? State some circumstances relative to it.

SECTION III.

CLASSIFICATION.

CHAPTER XXIX.

SYSTEM OF LINNÆUS.

333. *General Remarks.* — The vast number and the diversified forms of plants which each locality presents, suggest the necessity of some arrangement or classification, by which we may be enabled to distinguish and to name the species which occur to us, to retain their names and characters in our memory, and to communicate to others any points of common interest connected with them. The most superficial observer must have noticed that certain plants have so great a resemblance to one another that they arrange themselves, in the mind of the observer, without any effort of imagination, into natural groups. Thus the Grasses; the Cruciferous, the Labiate, the Leguminous Plants; the Ferns, and others, constitute as many groups, each with well-marked family resemblances, but no less evidently distinct from all others. Were the natural affinities of all plants as readily perceived as in these groups, the task of distributing them into families would be easy indeed. Such, however, is not the case; the points by which plants approach or recede from one another are sometimes so indistinct that the learner is liable, in many cases, to be bewildered in the inquiry; and hence the *Natural System*—the "consummation devoutly wished for" by every experienced botanist, is apt to alarm the student at the very period

when he requires most encouragement. These difficulties vanish in the *Artificial Method* of Linnæus: "the experience of nearly a hundred years," says Sir W. J. Hooker, "has proved to every unprejudiced mind that no system has appeared which can be compared with that of the immortal Swede for the *facility* with which it enables any one hitherto unpractised in botany to arrive at a knowledge of the genus and species of a plant."

334. It is certain that Linnæus viewed his own method merely in the light of a preface to a great work—as the scaffolding of a mighty building. But it *is*, what prefaces seldom are, very interesting; and it is *not*, what scaffoldings always are, cumbrous and complicated. Its great recommendation is its simplicity; although it comprehends all known plants, and is capable of comprehending all which may hereafter be known, it may be readily understood and remembered by young persons, while it imparts to them a facility and interest in arranging the plants which each locality presents. There is surely no exaggeration in saying that no one of ordinary capacity and liveliness of perception, who will devote an hour or two to the study of the Linnæan method, will fail of understanding and of being pleased with it; that few who understand and are pleased, will fail to commence an active inquiry into the products of the vegetable kingdom,—to become collectors of plants; and that some, at least, will be induced to proceed from the "preface" to the work itself; to advance from the "scaffolding" into the building—in other words, to step beyond the limits of an artificial method, and examine the profound and philosophical views developed by the natural system, as expounded in the works of Jussieu, De Candolle, Lindley, and others. Having said thus much of the comparative merits of the artificial and the natural methods of classifying plants, it is only necessary to state that the arti-

ficial method adopts four degrees of classification—the Class, the Order, the Genus, and the Species.

CLASSES OF THE LINNÆAN SYSTEM.

335. *Classes.*—In the Linnæan system plants are distributed into twenty-four classes, which are founded upon the number, position, and relative connection of the stamens. To the fanciful eye of Linnæus, the stamens and the pistils represented *sexes*—the former the male, the latter the female sex. Hence a flower which contained both the stamen and the pistil was called *hermaphrodite,* all other flowers being termed *unisexual.* Of the twenty-four classes of Linnæus, the first twenty have hermaphrodite flowers; the next three classes, unisexual flowers; the last has no flowers.

336. The *first eleven classes* are founded solely on the *number* of the stamens, and have Greek names, expressive of this distinction, the first class being termed *mon'andria,* the second *di'andria,* and so on to the tenth, *dec'andria.* As no flowers are known which have constantly eleven stamens, the eleventh class contains those which have twelve, and is, therefore, entitled *dodec'andria.* But as the genera which have this precise number are few, and as the number is uncertain when the stamens are numerous, all plants are comprehended in this class which have any number of stamens, from eleven to nineteen inclusive, provided they be disunited. It must be observed that in all these classes the stamens are separate from the pistil, from the calyx, from the corolla; and that they are of equal or of indeterminate length.

337. The *twelfth* and *thirteenth classes* are founded on the *number* and the *position* of the stamens. It is not enough to say that these two classes comprise all those plants which have twenty or more stamens; the position

or insertion of the stamens must be examined. It will be found that the stamens of a rose are inserted into the calyx, while those of a poppy are placed on the receptacle or expanded top of the flower-stalk. This is an important distinction, as will appear hereafter; but it is not expressed in the names of the two classes. The reader must be contented to know that the class *icosandria* comprises plants with twenty or more stamens *inserted into the calyx,* while the class *polyandria* includes those with twenty or more stamens *inserted into the receptacle.*

338. The *fourteenth* and *fifteenth classes* are founded on the *number* and *relative length* of the stamens. Hitherto we have supposed all the stamens to be of the same length, or nearly so; or, if not, still it has not been observed that there is any regular and determinate proportion in their length. This character is now to be considered:—1. If a flower of the dead-nettle be examined, the first thing that strikes the eye is the presence of four stamens; but the plant does not belong to the fourth class, for the stamens are arranged in one row, the inner pair being distinctly and constantly shorter than the outer pair. 2. If the blossom of a wall-flower be examined, it is immediately seen that it contains six stamens ; but the plant does not belong to the sixth class, for two of the stamens are shorter than the rest, and solitary, while four are larger and in pairs. To express these characters the terms *didynamia* and *tetradynamia* are employed, the former denoting that two, the latter that four stamens are stronger, because longer than the rest.

339. The *sixteenth, seventeenth,* and *eighteenth classes,* are founded on modes of *connection* subsisting between the *filaments* of the stamens. Hitherto all the stamens have been free, separate, disunited; but if a plant occur in which the stamens are united by their filaments,

while their anthers are disunited, it will certainly belong to one of the next three classes. 1. Let a flower of the common mallow be examined; the stamens are numerous, or, as they are usually called, indefinite; but the plant is neither icosandrous nor polyandrous, nor is there any occasion to look for the insertion of the stamens. A new character at once presents itself—all the filaments ot the stamens are united into *one set*, forming one regular membrane or tube below, while the anthers are free above. The fanciful mind of Linnæus saw in this combination a brotherhood, and he expressed it by the Greek word "adelphia." The class *monadelphia*, therefore, includes plants whose stamens are united by their filaments into a tube. 2. Now, let a flower of the common clover be inspected. Here the stamens are, indeed, definite—there are ten; but the plant does not belong to the tenth class, nor is it necessary to count the stamens, for it is instantly apparent that the filaments are combined. At first sight they *seem* to be monadelphous; but, upon closer examination, it will be found that nine of the stamens are united and one is free. Although it may fairly be questioned how unity can express brotherhood, yet *two sets*, two brotherhoods are here supposed, and the class is called *diadelphia*. The difficulty will vanish before the imagination. 3. Lastly, let a flower of St. John's wort be examined. Here are stamens indefinite, sometimes definite; but it matters not, there is no occasion to count them; the filaments are obviously combined, and that is sufficient. But in this case we have *three sets*, or *five sets*, or more; and the class has accordingly received the name *polyadelphia*.

340. The *nineteenth* class is founded on the *connection* of the *anthers* of the stamens; in this case the filaments are free, while the anthers are united into a tube. This class is called *syngenesia*, but the term is not sufficiently

precise; it denotes merely a growing together, without defining the parts of the organ which exhibit the phenomenon. The term *synantherous* would satisfy every wish. After all, the flowers of this class are very small, and the character just mentioned is not very striking; it may, therefore, be added that the flowers are called *compound*, and this one word is sufficient to overcome the whole difficulty connected with the subject, after a single examination of a plant of this class. We said "are called" compound, and we said so advisedly, for they are not compound; but we must not be too critical; the terms "compound" and "composite" are always applied to syngenesious plants, and *vice versâ*, and with this we must be satisfied for the present.

341. The *twentieth* class is founded on the *connection* subsisting between the *stamens* and the *pistil.* Though in the last four classes the stamens have been in some sort united, yet in these, as well as in all the preceding classes, they have been entirely separate from the pistil, so that the one organ might be removed without interfering with the other. But if a flower, as of an orchis, presents an arrangement which renders this impossible, owing to the stamens being situated upon the style or column of the pistil, above the germen or ovary, a new characteristic occurs, for which the term *gynandria* has been adopted—a term compounded of the two Greek words, respectively employed to designate the pistil and the stamen.

342. The *twenty-first*, *twenty-second*, and *twenty-third classes* are founded on modifications arising from *unisexuality* and *hermaphroditism.* These expressive terms must now be simply explained. Hitherto, we have been concerned with such plants only as have flowers with both stamens and pistils; these are called hermaphrodite flowers, from their containing the two reproductive organs

—the stamen, symbolized by the Greek Hermes, the pistil by the Greek Aphrodité. 1. But a plant may occur, as a spurge or a sedge, of which some of the flowers contain stamens without pistils, others pistils without stamens; such flowers are said to be *unisexual*, and they may, for the sake of convenience, be called respectively *staminiferous* and *pistilliferous*. To include all plants presenting this peculiarity Linnæus adopted the term *monœcia*—a Greek word simply meaning *one house*. Of course the individual plant is the house; each flower is viewed as an apartment; Hermes and Aphrodité are in the same house, but always in separate apartments. 2. But the estrangement may proceed further. The staminiferous and the pistilliferous flowers may be not merely separate from each other, but always found on distinct plants of the same species, as in the poplar and the hop. This class of plants is designated by the term *diœcia*, signifying *two houses*—Hermes in one, Aphrodité in the other. 3. There is yet another case: there may be plants in which the peculiarities of the two preceding classes are combined, with an additional character: stamens and pistils may occur separate or united, on the same or on different plants; in other words, complete and incomplete flowers, hermaphrodite and unisexual flowers may occur on the same plant, or on different plants of the same species. To the class which comprises such unusual associations the term *polygamia* has been devoted.

343. The *twenty-fourth* class is founded on the absence, or the obscure nature of the reproductive organs, as compared with those of all the other classes. Linnæus, in whose playful fancy the vegetable world shadowed forth the relations of the animal, dignified the twenty-three classes above described as consisting of *phanerogamic* plants—plants in which the essential organs of

reproduction are obvious to our senses; the last class, therefore, in which all is mystery, is designated by a term which simply suggests our ignorance, viz., *cryptogamia;* plants in which the organs of reproduction are concealed. These are the ferns, the mosses, the fungi, the sea-weeds. Among the last of these plants are found certain equivocal beings, which serve to connect together the animal and the vegetable kingdoms; they seem to belong indisputably to neither; sometimes they assume the characters of both; at other times, indifferently of either. Their germs take root and grow like plants, while their fruit seems to be possessed of voluntary motion, and to pass through a stage of animal existence, before it again takes root and produces another generation.

344. The foregoing remarks are thus condensed :—

	Class	
FLOWERS HERMAPHRODITE.	1. MONANDRIA..........	1 *Stamen* in each flower.
	2. DIANDRIA.............	2 *Stamens*, equal in length.
	3. TRIANDRIA............	3 „ „
	4. TETRANDRIA.........	4 „ „
	5. PENTANDRIA.........	5 „ „
	6. HEXANDRIA...........	6 „ „
	7. HEPTANDRIA.........	7 „ „
	8. OCTANDRIA...........	8 „ „
	9. ENNEANDRIA........	9 „ „
	10. DECANDRIA...........	10 „ „
	11. DODECANDRIA.......	12 to 19 „
	12. ICOSANDRIA..........	20 or more, inserted into the *calyx*.
	13. POLYANDRIA..........	20 or more, inserted into the *receptacle*.
	14. DIDYNAMIA...........	4; 2 long, 2 short.
	15. TETRADYNAMIA......	6; 4 long, 2 short; *flowers cruciform*.
	16. MONADELPHIA.......	*Filaments* united at the base into one set.
	17. DIADELPHIA..........	*Filaments* united into two sets.
	18. POLYADELPHIA......	*Filaments* united into three or more sets.
	19. SYNGENESIA..........	*Anthers* united. *Flowers compound.*
	20. GYNANDRIA...........	*Stamens* inserted on the *Pistil*.

	Class	
FLOWERS UNISEXUAL.	21. MONŒCIA..............	*Stamens* and *Pistils* in *separate flowers* on the *same plant*.
	22. DIŒCIA.................	*Stamens* and *Pistils* in *separate flowers* on two *separate plants*.
	23. POLYGAMIA...........	*Stamens* and *Pistils separate* in some flowers, *united* in others, either on the *same plant*, or *two* or *three* distinct plants.
	24. CRYPTOGAMIA........	*Fructification* concealed.

345. The classes of the Linnæan system may also be conveniently studied in the following table :—

CLASSES OF THE LINNÆAN SYSTEM.

PLANTS							CLASSES.
Plants	Sexual organs apparent	Flowers hermaphrodite	Stamens distinct from the Pistil	separate	in indeterminate proportion	number	1 Monandria.
							2 Diandria.
							3 Triandria.
							4 Tetrandria.
							5 Pentandria.
							6 Hexandria.
							7 Heptandria.
							8 Octandria.
							9 Enneandria.
							10 Decandria.
							11 Dodecandria.
						number and insertion	12 Icosandria.
							13 Polyandria.
					in determinate proportion		14 Didynamia.
							15 Tetradynamia.
				united	Filaments united		16 Monadelphia.
							17 Diadelphia.
							18 Polyadelphia.
					Anthers united		19 Syngenesia.
			Stamens united to the Pistil				20 Gynandria.
		Flowers unisexual					21 Monœcia.
							22 Diœcia.
							23 Polygamia.
	Sexual organs unknown						24 Cryptogamia.

ORDERS OF THE LINNÆAN SYSTEM.

346. The twenty-four classes of Linnæus are humorously designated by Rousseau as "twenty-four regiments," which must now be divided into their respective companies. "If," he observes, "you have patience to make a regular progress; to throw this multitude into large bodies; to subdivide these into smaller ones, and these again into others so small as to command them well with the eye, you have at length a regular army, which you can number, arrange, and discipline at your pleasure." To drop the military metaphor, we now proceed to divide the *Classes into Orders*—a task, perhaps, as agreeable as the former, though certainly less difficult. Generally speaking, knowledge loses half its charm when it can be acquired without difficulty. The orders of the first thirteen classes are founded on the *number of the styles*, or of the *stigmas*, when these are sessile; and, as every one can count styles or stigmas as easily as he can count stamens, the only tax on the memory is to familiarise it with the following terms, in which the word *gynia*, or pistil, is substituted for the word *andria*, or stamen. These are the orders:—

1. *Monogynia*, 1 style.
2. *Digynia*, 2 styles.
3. *Trigynia*, 3 styles.
4. *Tetragynia*, 4 styles.
5. *Pentagynia*, 5 styles.
6. *Hexagynia*, 6 styles.
7. *Heptagynia*, 7 styles.
8. *Octogynia*, 8 styles.
9. *Decagynia*, 10 styles.
10. *Polygynia*, many styles.

347. After the first thirteen classes the styles are no longer used for the purpose of subdividing the classes into orders. In the fourteenth class, *didynamia*, such a principle of subdivision would be utterly useless, because all the flowers belonging to this class have one pistil, and no more. Here Linnæus had recourse to another circum-

stance, which, though founded in error, has furnished one among the many proofs that successful error is not unpopular. The four little bodies, or prominences, which may be seen at the bottom of the calyx of the dead-nettle, and of most labiate plants, were mistaken by Linnæus for "naked seeds," seeds without a pericarp. Seeds they are not, but they are the four lobes of a deeply-divided pericarp, which contains four small nuts. But the error remains, and is likely to remain, in the word *gymnospermia,* which is employed to distinguish all such plants in this class from those furnished with a pericarp which no one can mistake, and which are, therefore, called *angeiospermia.* The plants composing the latter order have a two-celled pericarp, or capsule, containing an indefinite number of seeds. The orders of the fourteenth class may, then, be briefly described, as founded on the presence, or (supposed) absence, of a seed-vessel:—

1. *Gymnospermia ;* seeds 4, apparently naked; or more correctly, ovary 4-lobed.

2. *Angeiospermia ;* seeds in a distinct pericarp.

348. In the fifteenth class, *tetradynamia,* the flowers have also one pistil, and no more. Here the ordinal characters are again taken from the fruit. There are two familiar garden plants, wall-flower, and candy-tuft; the fruit of the former is long and narrow, that of the latter short and relatively broad. The former fruit is called a *siliqua,* the latter a *silicula.* It is desirable to avoid the word *pod,* because it is commonly applied to the legume of the pea and the bean. An ordinal character derived from the comparative length of a seed-vessel may appear trivial, and it may be sometimes hard to draw the line; but it is popular, and will rarely deceive. We have, then, the fifteenth class, divided into the following orders:—

1. *Siliquosa;* seeds in a long seed-vessel, or *siliqua.*

2. *Siliculosa;* seeds in a short seed-vessel, or *silicula.*

349. In the sixteenth, seventeenth, and eighteenth classes, *monadelphia, diadelphia,* and *polyadelphia,* the orders are founded on the *number of stamens* which compose each adelphia, or brotherhood. Here there is no difficulty; and, what is very pleasant, no new terms are required to burden the memory. The orders, accordingly, of these three classes are the following:—

1. *Triandria,* 3 stamens.
2. *Pentandria,* 5 stamens.
3. *Decandria,* 10 stamens.
4. *Polyandria,* many stamens.

350. The orders of the nineteenth class, *syngenesia,* are founded on the *structure of the flower,* and here, for the first time, attention is required. Let the student take a head of flowers from the three following plants, the dandelion, the daisy, and the blue-bottle:—1. On examining the dandelion, he will find that each floret presents a "strap-shaped corolla, tubular at the base, then slit on one side, so that the limb becomes flat;" through the tubular part of the corolla five stamens arise, with cohering anthers; and through the tube of the anthers arises the style with its cleft stigma; the whole is mounted upon the pistil. This structure is found in each floret of this plant: each floret is strap-shaped; each contains pistil and stamen; in a word, all the florets are *equal,* and hence all the plants which have equal and perfect florets belong to an order named *æqualis.* 2. But the daisy, when examined, is found to present two kinds of floret, differing in structure: those of the margin, or circumference, are strap-shaped, while those in the centre are tubular; the latter, or flowers of the *disk,* as they are called, are perfect, being furnished with both pistil and stamen; while the former, or flowers

of the *ray*, have a pistil, *but no stamen.* These, then, being imperfect, seem to be *superfluous;* and, hence, to all plants so characterized, the ordinal designation of *superflua* has been applied. 3. The blue-bottle exhibits a further modification: the florets of the disk are perfect, while those of the ray contain neither pistil nor stamen; they seem to be *of no use*, and to them the term *frustranea* has been devoted. Thus, we have the following orders:—

1. *Æqualis;* all the florets perfect.

2. *Superflua;* florets of the *disk* perfect; those of the *ray* pistilliferous only.

3. *Frustranea;* florets of the *disk* perfect; those of the *ray*, neuter.

351. "We have now," says Rousseau, "happily, I hope, passed *the fool's bridge*, and are arrived safely on the other side, where the way is plain, and we shall soon get pleasantly to the end of our stage." The orders of the three following classes are founded on the *number*, *union*, and *situation of the stamens*, and take their names accordingly from the foregoing classes. Thus the twentieth class, *gynandria*, is divided into the orders *monandria*, 1 stamen; *diandria*, 2 stamens; *hexandria*, 6 stamens. The twenty-first class, *monœcia*, in which the stamens and pistils are in separate flowers on the same plant; and the twenty-second class, *diœcia*, in which the stamens and pistils are in separate flowers and on different plants, are both distinguished into orders by the well-known principles conveyed by the terms *monandria*, 1 stamen; *diandria*, 2 stamens; *monadelphia*, stamens combined, &c.

352. The twenty-third class, *polygamia*, has three orders, founded on the three modes in which the three sorts of flowers are arranged in the same plant, or in

two plants, or in three. The names, which are familiar, are as follows:—

1. *Monœcia;* unisexual flowers accompanied by barren or fertile flowers, or both; all *on one plant.*

2. *Diœcia;* the same, on *two different plants.*

3. *Triœcia;* the same, on *three different plants.*

353. In the twenty-fourth class, *cryptogamia,* in which the organs of fructification baffle our theories, and even our sight, the plants have a very particular structure, which serves to furnish not only classical characters, but also ordinal subdivisions; the latter are, in fact, natural orders, or families. These are—

1. Ferns. 2. Mosses. 3. Lichens.
4. Fungi. 5. Algæ.

ORDERS OF THE LINNEAN SYSTEM.

354. 1. The *Orders* of the first thirteen classes are founded on the *number of styles:*—

1. *Monogynia,* 1 style.
2. *Digynia,* 2 styles.
3. *Trigynia,* 3 styles.
4. *Tetragynia,* 4 styles.
5. *Pentagynia,* 5 styles.
6. *Hexagynia,* 6 styles.
7. *Heptagynia,* 7 styles.
8. *Octogynia,* 8 styles.
9. *Decagynia,* 9 styles.
10. *Polygynia,* many styles.

2. The *Orders* of the fourteenth class are two, founded on the presence or (*supposed*) absence of a seed-vessel:—

1. *Gymnospermia;* seeds 4, apparently naked; or ovarium 4-lobed.
2. *Angeiospermia;* seeds in a distinct seed-vessel.

3. The *Orders* of the fifteenth class are two, founded on the comparative length of the seed-vessel:—

1. *Siliquosa;* seeds in a long seed-vessel, or siliqua.
2. *Siliculosa;* seeds in a short seed-vessel, or silicula.

4. The *Orders* of the sixteenth, seventeenth, and eighteenth classes are founded on the *number of stamens* in each adelphia, or brotherhood:—

1. *Triandria,* 3 stamens. 2. *Pentandria,* 5 stamens.
3. *Decandria,* 10 stamens. 4. *Polyandria,* many stamens.

5. The *Orders* of the nineteenth class are founded on the *structure of the flower:*—

1. *Æqualis;* all the florets perfect.
2. *Superflua;* florets of the *disk* perfect; of the *ray,* pistilliferous only.
3. *Frustranea;* florets of the *disk* perfect; those of the *ray,* neuter.

6. The *Orders* of the twentieth class are founded on the *number of the stamens:*—

1. *Monandria,* 1 stamen. 2. *Diandria,* 2 stamens, &c., &c.

7. The *Orders* of the twenty-first and twenty-second classes are founded on the *number, union,* and *situation of the stamens:*—

1. *Monandria,* 1 stamen. 2. *Diandria.* 2 stamens.
3. *Monadelphia,* &c.

8. The *Orders* of the twenty-third class are three, founded on the separation of the sexes in the same plant, or in different plants:—

1. *Monœcia;* unisexual flowers accompanied by barren or fertile flowers, or both, all on *one plant.*
2. *Diœcia;* the same, on *two different plants.*
3. *Triœcia;* the same, on *three different plants.*

9. The *Orders* of the twenty-fourth class are natural orders or families:—

1. *Filices.* 2. *Musci.* 3. *Hepaticæ.* 4. *Lichens.*
5. *Fungi.* 6. *Algæ.*

355. *Genus; Species; Variety.*—1. The classes having been divided into orders, the next step in classifica-

tion is to distribute the orders into genera. A *genus* is an assemblage of species, which present an obvious resemblance in the organs of fructification. Thus, the water ranunculus is a species with white flowers, the pilewort ranunculus has yellow flowers; the leaves of these two species differ considerably; the one grows in water, the other in meadows; yet they agree in the general character of their fruits; and there are fourteen or more species of ranunculus, which differ from one another in the forms of their leaves, and in various other matters; but all agree in the structure and arrangements of their fruits, and hence they constitute the universally recognised *genus* ranunculus. 2. As an order consists of genera, so a genus consists of species. A *species* is a collection of individuals, which present similar characters, and reproduce themselves with the same essential properties and qualities. Each individual water ranunculus resembles every other water ranunculus, more nearly than it resembles any other plant; we hence infer that they all sprang from a common stock, and are enabled to preserve their characters unchanged when propagated by seed. 3. A *variety* is an individual of the same species, presenting the same essential characters, but differing in some points, from accidental circumstances of little importance, as climate, soil, temperature, &c. These circumstances affect the size, the colour, or other unimportant characters of plants, without affecting the specific characters. When the particular cause ceases to operate, varieties generally revert to the common characters of the species..

RECAPITULATION.

333. What groups of plants present obvious family resemblances? 334. What are the advantages of the Linnæan system? 335. On what principle did Linnæus distribute

plants into classes and orders? 336. On what principle are the first eleven classes founded? 337. What is the precise distinction between the twelfth and thirteenth classes? 338. How are the fourteenth and fifteenth classes distinguished? 339. Explain the distinction of the sixteenth, seventeenth, and eighteenth classes. 340. How is the nineteenth class characterized? 341. State the peculiarities of the twentieth class. 342. What modifications are observed in the twenty-first, twenty-second, and twenty-third classes? 343. What is the principal character of the twenty-fourth class? 346. How are the first thirteen classes distributed into orders? 347. How is the fourteenth class divided? 348. How is the fifteenth distinguished? 349. What divisions occur in the sixteenth, seventeenth, and eighteenth? 350. Explain the orders of the nineteenth class. 351. Describe the ordinal characters of the twentieth, twenty-first, and twenty-second classes. 352. Explain the distinction of the twenty-third class. 353. How is the twenty-fourth class divided into groups? 355. What is a genus, a species, and a variety of plants?

CHAPTER XXX.

THE NATURAL SYSTEM.

356. *General Remarks.*—1. The divisions of plants adopted in the system of Jussieu, commonly called the *Natural System*, are not founded, like those of Linnæus, upon the number and modifications of a single organ, but upon the characters presented by all parts of plants collectively. On this principle, plants are grouped together which have a greater relation to those which immediately precede or follow them, than to any other. 2. Nature appears to have suggested such a system, in having stamped on many plants a marked character of

structure: the Gramineæ, the Labiatæ, the Cruciferæ, the Compositæ, the Umbelliferæ, present well-defined physiognomical characters; these groups of plants have, consequently, been always severally combined, except when their relations have been sacrificed to an artificial scheme. 3. The *advantages* of the Natural System are found in the general and philosophical ideas, which we are led to form from a comprehensive view of the entire vegetable kingdom. The *affinities* of plants are thus determined by a consideration of all the points of resemblance which occur in their various parts, properties, and qualities; and, consequently, the structure and quality of an imperfectly known plant may be determined by those of another which is well known.

357. *Species, Genus, Order, Class.*—The distinctive meanings attached by botanists to the terms Species, Genus, and Variety, have been already explained, § 355, and to that paragraph the reader is referred. *Orders*, or natural families, are formed of genera, as these are of species, and are founded on characters presented by all parts of plants—the seed, the fruit, the flowers, and the vegetative organs. The superficial observer little supposes that all the species of Ranunculus, all those of Anemone, all of Helleborus, all of Aquilegia, Aconitum, and several other genera, are members of the family typified by the Ranunculus, and hence called Ranunculaceous plants. *Classes* are the first division, and they consist each of a certain number of orders or natural families, united by a character more general and comprehensive, but always proper to each individual in the class. It is not pretended that there are any such positive arrangements in nature as genera and families. Nature creates only *individuals;* in these, the general organization is so modified, as to pass, by almost in-

sensible gradations, from the simplest to the most complicated structure. Observation has led to the discovery that many plants reproduce themselves constantly by seeds; this succession, viewed in an abstract and general manner, determines a *species*. Observation has further led us to classify a large number of species, differing from one another in certain points, but agreeing in some common characters, as of internal structure, into a group, which we call *genus*. By extending this principle of association, we arrive at *natural families*, or *orders*, founded on resemblances in all points of their organization. But these classifications have no positive existence in nature; they are the works of man. A *natural family*, then, is merely an assemblage of plants in which the species or genera form a kind of uninterrupted succession; in which the general organization passes insensibly from individual to individual, without any shock to disturb the harmony of nature. In this sense only can the term be applied to the systematic divisions of man.

358. *Divisions of Jussieu.*—The primary divisions are founded on the separation, the combination, and the absence of the petals, and are termed the *polypetalous*, the *monopetalous*, and the *apetalous* groups; to which is added a fourth, founded on the separation of the sexes in flowers having no petals, and termed *diclinous*. The first three are divided with reference to the insertion of the stamens, which are epigynous, perigynous, or hypogynous; further, the monopetalous epigynous group is subdivided into plants which have their anthers united, and those which have them distinct. Hence we have eleven classes:—

		Class.
Polypetalous	Stamens epigynous	1
	Stamens perigynous	2
	Stamens hypogynous	3

			Class.
Monopetalous	Corolla hypogynous	. . . . .	4
	Corolla perigynous	. . . . .	5
	Corolla epigynous	Anthers united	6
		Anthers distinct	7
Apetalous . .	Stamens epigynous	. . . . .	8
	Stamens perigynous	. . . . .	9
	Stamens hypogynous	. . . . .	10
Diclinous			11

359. *Divisions of De Candolle.*—De Candolle reduced the eleven classes of Jussieu to four; the first three being founded on the separation or cohesion of the several parts of the flower, the fourth on the suppression of the floral envelopes. Thus, in Thalamifloræ, all the parts are present and distinct from each other; in Calycifloræ, the stamens adhere to the calyx; in Corollifloræ, the petals cohere with each other; in Monochlamydeæ, the corolla is suppressed, and, in the most imperfect orders, the calyx also.

Polypetalous	Stamens hypogynous .	*Thalamifloræ.*
	Stamens perigynous .	*Calycifloræ.*
Monopetalous		*Corollifloræ.*
Apetalous		*Monochlamydeæ.*

360. *Relative Value of Characters.* — In order to establish a correct classification of plants into natural families, the *relative value* of the characters must be determined. In examining carefully a certain number of these groups, we observe that some of the characters are *constant and invariable;* that others are *generally constant;* that is, they are found in most of the groups; that others are *constant in some groups, and generally absent in others;* and that others have no *constancy,* but vary in every order. Thus we have four kinds of character, with reference to their constancy; and it is in direct ratio to its *constancy* that a character acquires

importance. To what organs should we, then, look for that degree of constancy, which is of primary importance?

(1.) Among the reproductive organs, the *embryo* is the most important, for the development of this crgan is the great object of vegetable life; and the embryo, when developed, is capable of perpetuating the species. But, like every other organ, the embryo presents characters of very unequal value. Of the first importance, obviously, are its presence or absence; its peculiar organization, or mode of development, which is a necessary consequence of this. The *embryo* furnishes two characters of the first importance, viz.:—1. Plants with or without embryo; 2. Plants with the cotyledonary extremity simple, or divided. Those plants which have the cotyledonary extremity simple, or, in other words, have a monocotyledonous embryo, have a coleorrhiza, and are called *endorrhizous;* those with the cotyledonary extremity divided, or, in other words, those which have a dicotyledonous embryo, have a naked radicle, and are called *exorrhizous.*

(2.) The *stamens* also furnish characters of the first importance. Their presence or absence needs not to be mentioned, as it corresponds always with the presence or absence of an embryo. The only constant character of the first sort is the relative position of those organs—that is, their *mode of insertion.* (See pp. 101, 102.)

(3.) The nutritive organs also furnish characters of the first importance. None of these organs are more important than the *vessels;* these are, however, absent from some plants. Hence, two characters: *cellular* plants, without vessels; and *vascular* plants. Again, the vessels are placed in the centre of the plant, increasing its bulk to the inner part; or they are placed exteriorly, and the growth takes place outwardly. Hence, vascular plants may be exogenous or endogenous.

361. *Correspondence of Characters.*—The characters

stamped upon the organs essential to the two functions of nutrition and reproduction, are equally important, as is evident from the correspondence existing between them. Thus, the divisions furnished by the embryo correspond exactly with those furnished by the vessels:—plants without embryo are also without vessels; those with embryo have also vessels. Monocotyledons or Endorrhizæ are endogenous; Dicotyledons or Exorrhizæ are exogenous. These are important coincidences. A certain modification of one organ constantly involves a certain modification of another: an inferior ovary, for instance, invariably involves a monosepalous calyx; a truly monopetalous corolla invariably involves the insertion of the stamens into the corolla itself; &c.

362. *Characters of less Constancy.*—But we do not find in all organs of plants characters so constant as those furnished by the embryo and the vessels. 1. The second sort consists of those which are *generally constant* throughout a family, or with few exceptions. To this sort belong the characters taken from the corolla, which may be monopetalous, polypetalous, or none; from the albumen, which may be present or absent; from the position of the embryo relatively to the seed; from that of the seed relatively to the pericarp. 2. In the third sort, the characters are *constant in some families and entirely absent in others.* To this sort belong the number and proportion of the stamens; the combination of their filaments into one, two, or several bundles; the internal structure of the fruit; the number of its cells; the mode of their dehiscence; the alternate or opposite position of the leaves; the presence of stipules, &c. 3. To the fourth sort, or those of *no constancy* at all, are referred the various modes of inflorescence; the forms of leaves, of the stem; the size of flowers, &c.

363. Such are the principles on which plants are

classified. All the organs are examined and compared, their characters studied, and genera are grouped into families accordingly. The characters of the first class—the *structure of the embryo*, the *organization of the stem*, the *insertion of the stamens*, ought to be rigorously the same in all genera of the same family. Those of the second kind may sometimes fail. Those of the third kind will generally be found combined in all the generic groups of the same natural order, but they are not indispensable in every case.

Recapitulation.

356. On what principle are plants grouped together in the Natural System? What indications of such a system are suggested by nature? What are the advantages of the Natural System? 357. Distinguish between the terms individual, species, and variety. Explain and illustrate the principle by which genera and orders are established. What are classes? 358. What are the primary divisions adopted by Jussieu, and on what characters are they founded? Upon what principle does his subdivision proceed? 359. How did De Candolle modify the classification of Jussieu? State and explain the terms adopted by De Candolle. 360. How many kinds of character are determined in classifying plants? On what does their relative value depend? Which is the most important of the reproductive organs? Why so? What characters are furnished by the embryo? Distinguish between exorrhizous and endorrhizous plants. What important character is derived from the stamens? What characters are derived from the nutritive organs? 361. Point out the coincidences of the characters derived from the nutritive and the reproductive organs. 362. Enumerate the characters of the second, of the third, and of the fourth sort. 363. Which of these characters must be rigorously the same in all the genera of a family?

described. All the organs are examined and described, their functions studied, and [illegible] are grouped [illegible] [illegible]

[illegible]

[illegible]

[illegible] of a [illegible]

GLOSSARY OF ADJECTIVE TERMS.

[*The Substantive Terms are fully explained in the body of the Work, and may be found by reference to the Index.*]

A.

Abruptly pinnate. When the petiole of a pinnate leaf has no terminal leaflet or tendril, as in orobus tuberosus.

Acaulescent. Stemless; applied to a plant in which the stem is apparently absent, and the leaves seem to rise from the root, as in cnicus acaulis.

Accumbent. Lying against anything, as the edges of the cotyledon against the radicle in some cruciferous plants.

Acerose. Sharp-pointed, tapering to a fine point, as the leaves of juniper.

Aciculate. Needle-shaped, as a crystal; or marked with fine needle-like streaks, as applied to surfaces.

Acinaciform. Scimitar-shaped; plane on the sides, with one border thick, the other thin, as the leaves of mesembryanthemum acinaciforme.

Aculeate. Prickly; applied to a surface covered with prickles, as the stem of rosa.

Acuminate. Pointed; tapering gradually to a point, as the leaf of salix alba.

Adnate. Grown to anything, as the anther to the filament in polygonum.

Adventitious. Anything developed out of the ordinary course, as aerial roots, extra-axillary buds, &c.

Aggregate. Crowded together, as the florets of the compositæ, the carpels of ranunculus, &c.

Alternately pinnate. When the leaflets of a pinnate leaf are placed alternately on the common petiole, as in potentilla rupestris.

Amphitropal. Anything curved round the body to which it belongs, as the embryo round the albumen, in the seed.

Amplexicaul. Stem-embracing, as applied to leaves which sheathe the stem.

Anatropous. Inverted; turned entirely over, as applied to the ovule of the apple.

Annulate. Ringed; surrounded by rings, as certain vessels in plants, &c.

Antitropal. Anything which has a direction contrary to that of the body to which it belongs, as applied to the direction of the embryo compared with that of the seed.

Apetalous. Having no petals; applied to plants which have only one floral envelope, as the laurel.

Apocarpous. When the carpels of a flower are distinct from each other, as distinguished from *syncarpous*, which denotes their cohesion.

Appendiculate. That which has appendages, as applied to the calyx of scutellaria, &c.

Arcuate. Bow-shaped; bent like the arc of a circle, as the legume of mendicago falcata.

Areolate. Divided into areolæ or small spaces, as applied to surfaces.

Aspergilliform. Brush-like; divided into minute ramifications, as the stigmas of grasses, certain hairs of the cuticle, &c.

Atropous. That which is not inverted, as applied to the ovule of the nettle, and synonymous with *orthotropous*.

Attenuate. Tapering; gradually diminishing in breadth, and terminating in a point.

Auriculate. Eared; having two rounded lobes at the base, as the leaf of salvia officinalis.

Axillary. That which grows out of an axil, as the leaf-bud of a plant.

B.

Baccate. Berried; having a juicy consistence, as the fruit of ribes.

Barbate. Bearded; covered with hairs resembling a beard, as applied to surfaces.

Bicongregate. Bigeminate, or arranged in two pairs, as the leaflets of mimosa unguis cati.

Bicrenate. Doubly crenate; when the crenate toothings of leaves are themselves crenate.

Bidentate. Two-toothed, as applied to the fruit or achenic of bidens.

Bifarious. Arranged in two rows, not necessarily opposite to each other; in this particular, the term is differenced from *distichous.*

Bifoliolate. When two folioles or leaflets are developed at the same point at the end of the petiole, as in zygophyllum fabago. The term is synonymous with *conjugate.*

Bifurcate. Twice-forked, as applied to the inflorescence of stellaria, and synonymous with *dichotomous.*

Bijugous. In two pairs, as applied to the leaflets of a pinnate leaf.

Bilobate. Two-lobed, as applied to the leaves of Bauhinia, &c.

Binate. Growing in pairs; a term synonymous with *bifoliolate.*

Bipartite. Parted in two, as applied to the segments of a leaf.

Bipinnate. When the leaflets of a pinnate leaf themselves become pinnate, as in fumaria officinalis.

Biserrate. Doubly-sawed, as applied to the margins of leaves, when the serrations are themselves serrate.

Biserial. Arranged in two series, or rows; a term synonymous with *bifarious.*

Biternate. When three secondary petioles proceed from the common petiole, and each bears three leaflets, as in fumaria bulbosa.

Brachiate. Armed; applied to branches which diverge nearly at right angles from the stem.

C.

Caducous. Falling off early or readily, as the calyx of poppy; and opposed to *persistent,* which denotes permanence.

Cæspitose. Growing in tufts; forming dense patches, or tufts, as the young stems of many plants.

Calcarate. Having a calcar, or spur, as the petals of aquilegia.

Calyculate. Having an involucrum of bracts exterior to the calyx, as in many compositæ.

Calyptrate. Having a calyptra or hood, as the fructifying organ of mosses, the calyx of eschscholtzia, &c.

Campanulate. Having the form of a campanula or little bell, as applied to the corolla.

Campylotropous. Bent upon itself, as applied to the ovule of caryophyllaceous plants, &c.

Canaliculate. Channelled; long and concave, as the leaves of tradescantia virginica.

Cancellate. Latticed; applied to a leaf which has veins without connecting parenchyma, as in hydrogeton fenestralis.

Capitate. Headed; applied to hairs which terminate in a glandular enlargement.

Carinate. Having a carina, or keel, as the glumes of grasses, the two lowest petals of a papilionaceous corolla.

Carnose. Of a fleshy consistence, as applied to succulent leaves, &c.

Caudate. Tail-pointed; prolonged into a long and weak tail-like point, as certain petals, &c.

Cauline. Belonging to the caulis, or stem, as applied to leaves.

Centrifugal. Leaving the centre; applied to inflorescences, in which the central flowers open first.

Centripetal. Approaching the centre; applied to inflorescences in which the marginal flowers open first.

Cernuous. Drooping; inclining from the perpendicular towards the horizon; applied to flowers.

Ciliated. Fringed with hairs, like an eye-lash, as applied to the margin of leaves.

Circinate. Rolled inwards from the point to the base, like a lock of hair, as the fronds of ferns.

Circumscissile. Divided across by a transverse separation, as the capsule of hyoscyamus.

Cirrhose. Anything which terminates in a tendril, or filiform appendage, as the leaf of several leguminous plants.

Clavate. Club-shaped; thickest at the upper end, as applied to filaments, styles, the vittæ of umbelliferous plants, &c.

Clypeate. Shield-shaped, as the scales of the leaves of elæagnus, and synonymous with *scutate,* or scutiform.

Cochleate. Shell-shaped; shortly spiral, like a snail's shell, as the legume of medicago cochleata, &c.

Comose. Having como or hair at the extremity, as the seed of asclepias.

Conduplicate. Doubled together; a form of vernation or æstivation, in which the sides of a leaf or petal are applied parallelly to the faces of each other.

Confluent. Growing together; the cohering of homogeneous parts; synonymous with *connate*, cohering, &c.

Conjugate. Yoked together; growing in a pair, as the two leaflets of the pinnated leaf of zygophyllum fabago.

Connate. Growing together, or cohering, as two opposite leaves on the stem.

Connivent. Converging; having a direction inwards, as the anther of solanum tuberosum.

Contorted. Twisted in such a manner that each piece of a whorl overlaps its neighbour by one margin, and is overlapped by its other neighbour by the other margin, as in the æstivation of oleander.

Convolute. Rolled together; a form of æstivation or vernation, in which one petal or leaf is wholly rolled up in another.

Cordate. Heart-shaped; having two rounded lobes at the base, as applied to leaves.

Coriaceous. Of a leathery consistence, as the leaves of prunus laurocerasus.

Corneous. Of a horny consistence, as the albumen of many plants.

Corniculate. Horned; terminating in a horn-like process, as the fruit of trapa bicornis.

Corrugate. Wrinkled; folded up in every direction, as in the æstivation of poppy.

Corymbose. That arrangement of the ramifications of plants, in which the lower branches or pedicles are so long as to bring the leaves or flowers to the same level as that of the upper ones.

Crenate or *crenelled.* Having rounded teeth; applied to the edges of certain leaves.

Crested. Having a helmet-like ridge, as applied to seeds.

Cruciate or *cruciform.* Placed crosswise, as the floral envelopes of brassica.

Cucullate. Hooded; having the apex and sides curved inward, as the upper sepal of aconitum.

Cuneate or *cuneiform.* Wedge-shaped; inversely triangular, with rounded angles, as applied to certain leaves.

Cuspidate. Spear-shaped; tapering to a stiff point; abruptly acuminate; as applied to leaves.

Cyathiform. Cup-shaped; as applied to the form of some corollas.

Cymbiform. Boat-shaped, or navicular, as applied to the glumes of certain grasses, and synonymous with *carinate.*

Cymose. Resembling a cyme, as applied to inflorescences and leafy branches.

D.

Deciduous. Falling off; synonymous with caducous, and opposed to *persistent*, which denotes permanence.

Declinate. Bent downwards; applied to the stamens, when they all bend to one side, as in amaryllis.

Decumbent. Lying prostrate, but rising from the earth at the upper extremity, as applied to the directions taken by plants.

Decurrent. Running down; applied to leaves which are prolonged down the stem, giving it a winged appearance.

Decussate. Crossing at right angles, as pairs of leaves on the stem.

Dehiscent. That which opens spontaneously, as the thecæ of anthers, capsular fruits, &c.

Deliquescent. Melting away; applied to a panicle which is so much branched that the primary axis disappears.

Deltoïd. Shaped like the Greek letter delta, as applied to certain leaves.

Dentate. Toothed; having sharp teeth with concave edges.

Depauperated. Starved; imperfectly developed; shrivelled, as from scanty nutriment, as applied to certain stipules, bracts, &c.

Depressed. Flattened from apex to base, as applied to seeds; when flattened lengthwise, they are said to be *compressed.*

Diadelphous. Having the stamens arranged in two distinct fasciculi.

Diandrous. Having two stamens, of about the same length.

Dichotomous. Having the ramifications always in pairs, or bifurcations, as stellaria.

Dicotyledonous. Having two cotyledons or seed-lobes, as applied to the embryo.

Didynamous. Having two pairs of stamens of unequal length.

Didymous. Twins; growing in pairs; as the fruit of galium.

Digitate. Fingered; diverging from a common centre; as the lobes of the leaf of horse-chestnut.

Dimidiate. Halved; half-formed; partially formed; having one side only perfect, as a leaf, an anther, &c.

Diœcious. Having stamens on one plant, and pistils on another.

Dipterous. Two-winged; as applied to the two margins which are prolonged on the surface of certain seeds.

Distichous. Arranged in two rows, as the florets of many grasses, and synonymous with *bifarious.*

Divaricating. Spreading out nearly at a right angle from anything, as branches from a stem.

Dodecandrous. Having twelve stamens, of about the same length.

Dolabriform. Hatchet-shaped; as applied to the leaves of a species of mesembryanthemum.

Drupaceous. That kind of fruit which has an indehiscent pericarp, fleshy externally, bony internally, as the peach.

Dumose. The character of a shrub which is low and much branched.

E.

Echinate. Bristly, covered with stiff hairs or prickles, like an echinus; as the fruit of the sweet chestnut.

Emarginate. Having a notch at the upper extremity, as if a portion had been cut out of the margin, as the leaf of box.

Endogenous. Inside-growing; increasing in diameter by depositions to the centre.

Endorrhizous. That mode of germination in which the radicles are emitted from within the substance of the radicular end of the embryo, and are, in fact, *sheathed.*

Enneandrous. Having nine stamens of about equal length.

Ensiform. Sword-shaped; straight, flat, and pointed, as the leaf of iris.

Entire. Having no marginal division, as applied to the leaves of galium.

Epigeous. Growing on the earth; applied to cotyledons which emerge from the ground.

Epigynous. Inserted upon the summit of the ovarium, as applied to stamens.

Equally pinnate. When the petiole has no terminal leaflet or tendril; synonymous with *abruptly pinnate.*

Equitant. A form of vernation in which the leaves overlap each other parallelly and entirely, without involution, as in iris.

Erose. Gnawed; having the margin irregularly divided, as if bitten by some animal; applied to leaves.

Exogenous. Outside-growing; increasing in diameter by additions to the exterior.

Exorrhizous. That mode of germination in which the radicle is not contained within the substance of the embryo, and consequently is not enclosed in a sheath.

Extrorse. Turned outwards; turned away from the axis to which it belongs; applied to certain anthers.

F.

Falcate. Sickle-like; anything plane and curved, with parallel edges, as the legume of medicago falcata.

Farinaceous. Mealy; of the nature of flour; as the albumen of wheat.

Fasciated. Banded; grown unnaturally together, as contiguous stems, or fruits.

Fasciculate. Clustered; as when several bodies spring from a common point, as the leaves of larix, the tubers of orchis, the roots of commelina, &c.

Fastigiate. When the branches of a tree are appressed to the stem, assuming nearly the same direction, as in populus fastigiata.

Favose. Honeycombed; excavated like a honeycomb, as the receptacle of onopordum, the seeds of poppy, &c.

Fenestrate. Windowed; as applied to the incomplete dissepiment sometimes occurring in the siliqua of cruciferous plants.

Filiform. Thread-like; as applied to the filaments, and the styles, of plants.

Fimbriated. Fringed; having the margin bordered by filiform processes.

Fistulous. Cylindrical and hollow, as the stems of grasses, of umbelliferous plants, &c.

Flabelliform. Fan-shaped; plaited like the rays of a fan, as the leaves of some palms.

Flagelliform. Whip-like; long, taper, and supple, as the stems or roots of certain plants.

Flexuose. Wavy; bending alternately inwards and outwards.

Floccose. Covered with tufts of woolliness, as the leaves of some species of verbascum.

Foliaceous. Leaf-like; having the form and texture of a leaf, as certain floral envelopes.

Fugacious. Falling off, or perishing rapidly, as the petals of cistus, minute fungi, &c.

Fungiform. Having a rounded, convex head, like that of a mushroom.

Fusiform. Spindle-shaped; thickest in the middle, and tapering to both ends, as the cells composing woody fibre.

G.

Galeate. Arched like a helmet; as applied to the upper lip of some labiate corollas, as that of lamium album.

Gamopetalous. Having the petals united; commonly termed monopetalous.

Gamosepalous. Having the sepals united; commonly termed monosepalous.

Geniculate. Knee-jointed; bent abruptly in the middle, as the stems of some grasses.

Gibbous. That which has a convex outline, as applied to solid bodies.

Glabrous. Smooth; having a surface free from hairs or any asperities.

Gladiate. Sword-shaped; a term of the same signification as *ensiform.*

Glandular. Covered with glanduliferous hairs, as the leaves of sweet-briar.

Glaucous. Azure-coloured; covered with bloom, like a plum.

Glumaceous. Having the floral envelopes reduced to scales, called glumes, as in grasses.

Grumous. Knotted, collected into granular masses, as the fæcula of the sago palm.

Gymnospermous. Having the seeds apparently naked, as distinguished from *angeiospermous*, which denotes the presence of a seed-vessel.

Gynobasic. That state of the carpels, in which they incline obliquely towards the axis of the flower, as in rue.

Gyrate. Curved in, from apex to base, as the fronds of ferns, and synonymous with *circinate.*

H.

Hastate. Halberd-headed; applied to leaves which have three lance-shaped lobes, one in the direction of the midrib, the other two at the base at right angles to the first, as in arum maculatum.

Heptandrous. Having seven stamens, of about equal length.

Herbaceous. Having the characters of a herb, the tissue for the most part green and cellular.

Heterotropal. That direction of the embryo, in which it lies across the seed, as in primrose.

Hexandrous. Having six stamens, of about equal length.

Hirsute. Hairy; covered with long and rather rigid hairs.

Hispid. Covered with long rigid hairs, as the stem of echium vulgare.

Homotropal. Having the same direction as the body to which it belongs, but not being straight; as applied to the embryo of the seed.

Hypocrateriform. Salver-shaped; as applied to a calyx or corolla, of which the tube is long and slender, and the limb flat, as in phlox.

Hypogeous. Subterranean; as applied to those cotyledons, which remain beneath the earth; and opposed to *epigeous.*

Hypogynous. Inserted beneath the pistil, as applied to the stamens, the corolla, &c.

I.

Icosandrous. Having twenty or more stamens inserted into the calyx.

Imbricated. A form of æstivation, or vernation, in which the pieces overlap each other parallelly at the margins, without any involution.

Impari-pinnate. Pinnate with an odd one; when the petiole of a pinnate leaf is terminated by a single leaflet, as in mountain-ash.

Incumbent. That which lies upon anything, as when the cotyledons of some cruciferous plants are folded with their backs upon the radicle. See *Accumbent.*

Indehiscent. Not opening spontaneously; as applied to certain ripe fruits.

Induplicate. A form of vernation or æstivation, in which the margins of the leaves are bent abruptly inwards, and the external face of these margins applied to each other, without any twisting.

Inermis. Unarmed; as applied to parts which have no spines or prickles.

Inferior. A term applied to the ovarium or fruit, when the calyx adheres to its walls; when no such adhesion occurs, the ovarium or fruit is termed *superior.* So also the calyx is said to be *inferior* in the latter case, *superior* in the former.

Infundibuliform. Funnel-shaped; applied to an organ with an obconical tube, and an enlarged limb, as the corolla of tobacco.

Innate. Growing upon anything by one end, as when the anther is attached by its base to the apex of the filament.

Intercellular. That which lies between the cells, or elementary tissues, of plants.

Interrupted. A term denoting a disturbance of a normal arrangement; a leaf is said to be *interruptedly pinnate,* when some of the pinnæ are much smaller than the rest, or absent.

Introrse. Turned inwards; as applied to anthers whose line of dehiscence is towards the axis of the flower, and as opposed to *extrorse.*

Involute. A form of vernation or æstivation, in which the edges of the leaves are rolled inwards spirally on each side, as in the apple.

L.

Labiate. Lipped; divided into two lips, as the corolla of lamium, the calyx of prunella, &c.

Laciniate. Slashed; as a leaf divided by deep, taper-pointed incisions.

Lacunose. Having large deep lacunæ or depressions on the surface.

Lanceolate. Lance-shaped; narrowly elliptical, tapering to each end, as the leaf of the mezereon.

Lenticular. Lens-shaped; small, depressed, and doubly convex, as the seed of amaranth.

Lepidote. Leprous; covered with minute peltate scales, as the leaves of elæagnus.

Ligneous. Woody; having the structures and other characters of wood.

Ligulate. Strap-shaped; narrow, somewhat long, with the two opposite margins parallel, as the florets of taraxacum.

Linear. Narrow, with the two opposite margins parallel, as the leaf of a pine.

Loculicidal. That mode of dehiscence of fruits, in which the loculi, or cells, are severed at their back.

Lunate. Crescentiform, or semilunar; having the form of a crescent.

Lyrate. Lyre-shaped; applied to a leaf which has several sinuses on each side, gradually diminishing in size from above downwards, as in charlock.

M.

Marcescent. Withering or fading, some time before it falls off, as the flowers of orobanche.

Medullary. A term applied to radii proceeding from the medulla to the bark, in exogenous stems.

Monadelphous. In one adelphia, or combination, as the stamens of malva.

Monandrous. Having only one stamen: the first class in Linnæus's system.

Moniliform. Necklace-like; cylindrical, and contracted at regular intervals, as the lomentum of ornithopus.

Monocotyledonous. Having only one cotyledon, or seed-lobe, as a palm.

Monopetalous. Having a single petal; or, more correctly, consisting of several cohering petals, and therefore better expressed by the term *gamopetalous.*

Monosepalous. Having a single sepal; or, more correctly, consisting of several cohering sepals, and therefore better expressed by the term *gamosepalous.*

Mucronate. Abruptly terminated by a hard short point; applied to leaves.

Multifid. Cut into many parts; applied to leaves which have numerous shallow segments.

Multipartite. Divided into many parts; applied to leaves which have many deep lobes.

Muricated. Covered with numerous short hard prominences, as the pericarp of ranunculus arvensis.

Muriform. Wall-like; applied to the tissues constituting the medullary rays, from its presenting an appearance similar to that of bricks in a wall.

N.

Napiform. Turnip-shaped; having the figure of a depressed sphere.

Navicular. Boat-shaped; concave, tapering to both ends, with a keel externally, as the glumes of some grasses.

Nutans. Nodding; inclining from the perpendicular, with the upper extremity pointing downward, as the flower of galanthus.

O.

Obvolute. A form of vernation or æstivation, in which the margins of one leaf alternately overlap those of the leaf which is opposite to it.

Octandrous. Having eight stamens of nearly equal length.

Operculate. Having an operculum or lid, as the theca of mosses, the calyx of eucalyptus, &c.

Orbicular. Completely circular, as the leaf of cotyledon orbiculare.

Orthotropal. Straight, and having the same direction as the body to which it belongs; as applied to the embryo of the seed.

Orthotropous. Erect; applied to the ovule, when it is rectilinear, and its base is in contact with the hilum.

Oscillating. Versatile; swinging backwards and forwards, from being nicely balanced by its middle; as applied to some anthers.

Ovate. Egg-shaped; oblong or elliptical, and broadest at the lower end; as applied to leaves.

P.

Paleaceous. Chaffy; covered with paleæ, or membranous scales, as the receptacle of some compositæ.

Palmate. A form of leaf, having five lobes, with the midribs radiating from a common point at the base of the leaf, and resembling the palm of the hand.

Palmatifid. A variety of the palmate leaf, in which the lobes are divided as far down as half the breadth of the leaf.

Palmatipartite. A variety of the palmate leaf, in which the lobes are divided beyond the middle, and the parenchyma is not interrupted.

Palmatisected. A variety of the palmate leaf, in which the lobes are divided down to the midrib, and the parenchyma is interrupted.

Palmatilobate. A variety of the palmate leaf, in which the lobes are divided to an uncertain depth.

Panduriform. Fiddle-shaped; obovate, with a deep sinus on each side, as the leaves of rumex pulcher.

Papilionaceous. Butterfly-shaped; a form of corolla characteristic of the leguminous plants of Europe.

Parietal. Belonging to or developed from the parietes or walls of an organ.

Pari-pinnate. Equally pinnate, abruptly pinnate; when the petiole of a pinnate leaf is terminated by neither a leaflet nor a tendril.

Partite. Parted or divided into a fixed number of segments, which are divided nearly down to the base, as applied to leaves: a leaf with two divisions is called *bipartite;* with three, *tripartite;* with many, *pluripartite,* &c.

Pectinate. A modification of the pinnatifid leaf, in which the segments are long, close, and narrow, like the teeth of a comb.

Pedate. A modification of the palmate leaf, in which the two lateral lobes are themselves subdivided, as in helleborus niger. The same modifications occur as in the palmate leaf, with similar terms, as pedatifid, pedatipartite, pedatisected, and pedatilobate.

Peltate. Shield-shaped; applied to leaves which are fixed to the petiole by their centre, or by some point within the margin, as in tropæolum.

Pentandrous. Having five stamens, of about equal length.

Perennial. Lasting for several years, as differenced from annual and biennial.

Perfoliate. A designation of a leaf, which, by union of its margins, incloses the stem, which thus seems to pass through it.

Perigynous. Growing from the sides of the calyx, and thus surrounding the ovarium, as applied to the stamens.

Peritropal. Directed from the axis to the horizon, as applied to the embryo of the seed.

Persistent. Not falling off, but remaining green for a long time, as the calyx of labiate plants, what are called evergreen leaves, &c.

Personate. Masked; a form of the gamopetalous corolla, resembling a mask with an open mouth.

Petaloid. Resembling a petal; as

some of the filaments of nymphæa, the stigmas of iris. &c.

Pilose. Covered with long, soft, and erect hairs, as applied to surfaces; or consisting of hair-like processes, as the limb of the calyx in composite plants.

Pinnate. That form of leaf in which simple leaflets are placed on each side of a common petiole, as in polypody. The same modifications occur as in the palmate leaf, with similar terms, as pinnatifid, pinnatipartite, pinnatisected, and pinnatilobate.

Plaited. A form of æstivation or vernation, in which the leaves are folded lengthwise, like the plaits of a fan, as in many palms.

Polyadelphous. Arranged in several fasciculi, as applied to stamens.

Polyandrous. Having an indefinite number of stamens, inserted beneath the pistil.

Polypetalous. Having several petals, distinct from each other.

Polysepalous. Having several sepals, distinct from each other.

Præmorse. Abruptly bitten off: the appearance presented by the main root of scabiosa succisa.

Pubescent. Covered with down or pubescence, consisting of short, soft hairs, as applied to surfaces.

Pyriform. Pear-shaped; inversely conical.

Q.

Quincunx. A form of æstivation or vernation, in which there are five leaves, two of which are exterior, two interior, and the fifth covers the interior with one margin, while its other margin is covered by the exterior, as in rose.

R.

Radical. Arising from the radix, or root as applied to the leaves of what are called acaulescent plants.

Ramentaceous. Covered with ramenta, or brown shrivelled scales, as the stems of many ferns.

Ramose. Branched; having many ramifications; when only somewhat branched, the term *subramose* is used.

Reniform. Kidney-shaped; crescent-shaped, with the ends rounded; applied to leaves and seeds.

Replicate. A form of vernation or æstivation, in which the upper part of the leaf is curved back and applied to the lower, as in aconite.

Reticulate. Netted; as applied to the vernation of the leaves of exogenous plants.

Revolute. A form of vernation or æstivation, in which the edges of the leaf are rolled backwards spirally on each side, as in rosemary.

Ringent. A term synonymous with *personate*, and indicative of the gaping appearance of the corolla.

Rostrate. Beaked; terminating in a long, hard process, as the siliqua of sinapis.

Rosulate. Having the leaves or other parts arranged in clusters, like the petals of a double rose, owing to contraction of the internodes of the stem.

Rotate. Wheel-shaped; applied to a calyx or coralla, of which the tube is very short, and the segments spreading, like the radii of a wheel, as in borago.

Ruminated. A term applied to the albumen in certain cases, in which it is perforated in various directions by dry cellular tissue, as in nutmeg.

Runcinate. Hook-backed; having its segments pointing downwards, like the teeth of a saw, as the leaf of taraxacum.

Rupturing. A mode of dehiscence, in which the pericarp is spontaneously perforated by holes, as in antirrhinum.

S.

Sagittate. Arrow-headed; applied to leaves which are pointed at the apex, and gradually enlarge at the base into two acute lobes, as in sagittaria.

Scabrous. Rough; covered with hard short projections from the cuticle, as the leaves of symphytum.

Scarious. Dry, thin, and shrivelled, as the bracts of the involucrum of centaurea.

Scrobiculate. Having numerous small irregular pits or depressions, as certain seeds.

Scutiform or *scutate.* Buckler-shaped; as the scales constituting the scurfiness of the leaves of elæagnus.

Semi-amplexicaul. Half stem-embracing; applied to leaves which partially sheath the stem.

Semi-anatropous. A term denoting the same as *amphitropous*, except that

in the former the ovule is parallel with the funiculus, while in the latter it is at right angles with it.

Septicidal. That kind of dehiscence in which the septa of a compound fruit separate each into two laminæ.

Septifragal. That kind of dehiscence in which the backs of the carpels separate from the septa, which adhere to the axis.

Sericeous. Silky; covered with long, fine, appressed hairs, giving the surface a silky appearance.

Serrate. Sawed; having the edge divided into sharp straight-edged teeth, pointing upwards like a saw. When the serrations are themselves serrate, the margin of the leaf is termed *biserrate.*

Sessile. That which is seated upon anything; a leaf is sessile on the stem when it has no petiole; an anther is sessile which has no filament, &c.

Setose. Bristly; covered with short, stiff hairs, as the leaves of bugloss, the pappus of some composite plants, &c.

Sinuate. Having a wavy margin, irregularly convex and concave.

Spadicose. Having the organs of reproduction arranged upon a spadix, as arum.

Spathaceous. Having the organs of reproduction inclosed within a spathe, or large sheathing bract, as arum.

Spatulate. Like a spatula; oblong, with the lower end much contracted, as the leaf of daisy.

Squarrose. Consisting of parts which spread out at right angles from a common centre; applied to leaves, &c.

Stellate. Star-like; applied to the leaves of galium, the hairs of most malvaceous plants, &c.

Stipitate. Stalked; that which is furnished with a stalk, as the pappus of some composite plants. The term does not apply to the petiole of a leaf, or the peduncle of a flower.

Stipulate. Furnished with stipules, *exstipulate,* having no stipules.

Strigose. A term applied to a surface which is covered with stiff hairs.

Strophiolate. A term applied to the umbilicus of seeds, when they are surrounded by irregular protuberances, called strophiolæ or carunculæ.

Stupose. Having a tuft of hairs at some part, as certain filaments, &c.

Subulate. Awl-shaped; linear, tapering to a fine point, as the leaves of ulex.

Succulent. Very cellular and juicy, as the stem of cactus, the leaf of sempervivum, &c.

Superior. A term applied to the fruit when it has no cohesion with the calyx, the latter being then termed *inferior.* Contrariwise, a cohering calyx is termed superior, the invested fruit being then termed inferior.

Sutural. A mode of dehiscence, in which the suture of a follicle or legume separates spontaneously.

Synantherous. Growing together by the anthers; the characteristic feature of the compositæ, and a more expressive term than the more common one, *syngenesious.*

Syncarpous. A term applied to a compound fruit, in which the carpels are grown together, as in poppy.

Syngenesious. Growing together, as applied to the anthers of compositæ. *Synantherous* is a better term.

T.

Terete. Taper; as applied to stems, and distinguished from angular.

Ternate. A term applied to parts which are united in three leaves, as leaves, &c.

Tetradynamous. Having six stamens, of which two pairs are longer than the third pair.

Tetrandrous. Having four stamens, of about equal length.

Tomentose. Covered with tomentum, or short close down.

Torulose. Knotted; irregularly contracted and distended, as applied to cylindrical bodies, or seed-vessels.

Trapeziform. Four-sided, with the opposite margins not parallel, as certain leaves.

Triadelphous. Having the stamens disposed in three parcels or fasciculi.

Triandrous. Having three stamens of about equal length.

Trichotomous. Having the divisions or ramifications always in threes, as mirabilis jalapa.

Tripinnate. A term applied to a leaf in which there are three series of pinnation; viz., when the leaflets of a bipinnate leaf are themselves pinnate, as in thalictrum minus.

Triternate. A term applied to a leaf in which there are three series of ternation; viz., when the leaflets of a biternate leaf are themselves ternate.

Truncate. Terminating very abruptly, as if a portion had been cut off, as the leaf of tulip-tree.

Turbinate. Top-shaped; inversely conical, and contracted towards the point.

U.

Unguiculate. Clawed; a term applied to a petal furnished with an unguis or claw, as in pink.

Urceolate. Pitcher-shaped; as applied to the envelope formed by the two confluent bracts of carex, to certain corollas, &c.

V.

Vascular. The name of a tissue, consisting of spiral vessels and their modifications, or ducts.

Ventral. A term applied to that suture of the legume to which the seeds are attached; the opposite suture is the *dorsal.*

Ventricose. Bellying; inflated in some parts, as applied to certain corollas, &c.

Verrucose. Warty; covered with little excrescences or warts.

Versatile. Swinging backwards and forwards, as applied to anthers, and synonymous with *oscillating.*

Verticillate. Whorled; a term denoting that arrangement of leaves in which three or more are placed opposite to each other in the same plane.

Villous. Covered with long, soft, shaggy hair, as epilobium hirsutum.

Voluble. Twisting; as applied to stems which twist round other bodies, the hop to the right, the bindweed to the left.

W.

Whorled. A term synonymous with *verticillate.*

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